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VOLUME 16 AUGUST 1937 NUMBER 8

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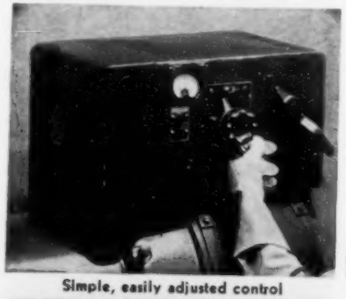

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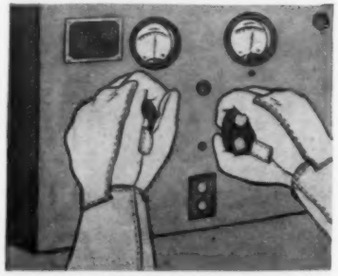

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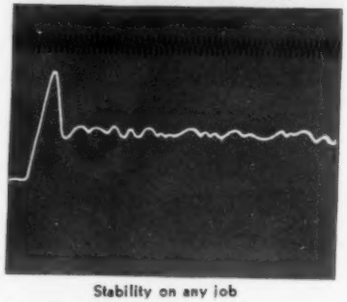

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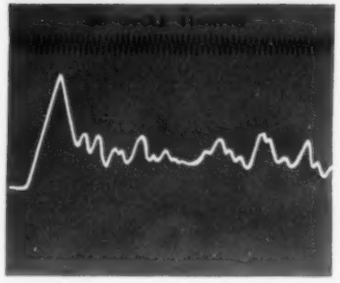

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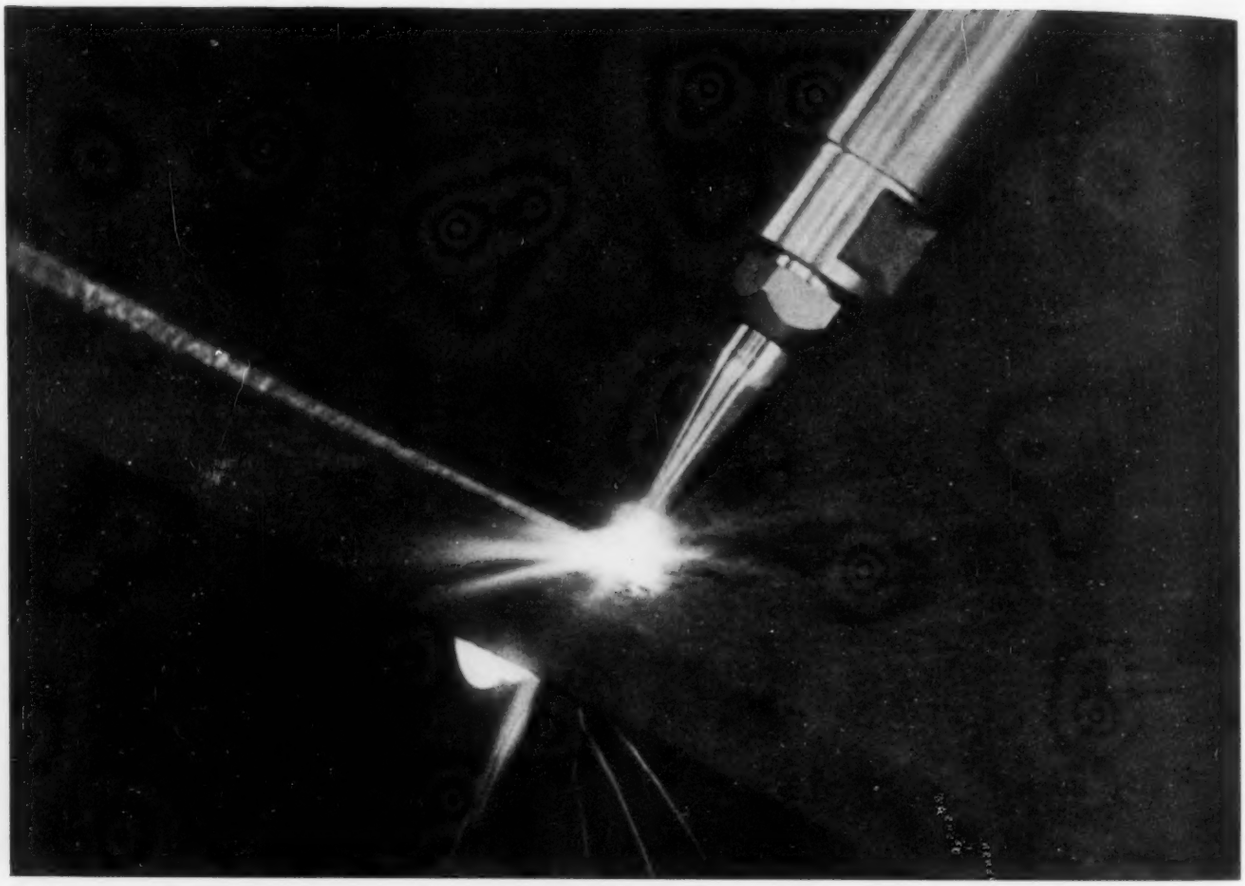


A New Technique Is Necessary for Cutting Clad Steels

How to Cut Stainless-Clad and Nickel-Clad Steel Plate

By H. V. INSKEEP†

Satisfactory Technique Developed Which Simplifies Plate Edge Preparation for Fabrication

DEVELOPMENT of a procedure for the oxyacetylene cutting of stainless-clad and nickel-clad steels has facilitated the preparation of these steels for fabrication. These clad materials are extensively used, particularly in the construction of process equipment, where the corrosion resistance of the cladding layer is desired in conjunction with the economies of the low-carbon steel base.

A great deal of this material is fabricated by welding just as is mild steel plate. Oxyacetylene cutting and beveling of the latter material are common shop operations. Cutting and beveling of the clad plate are likewise carried out today, but the technique used for ordinary steel is unsuitable for work on stainless-clad plate, and, therefore, a different technique is required.

At the present time it is shop practice to work from the stainless steel side. The desired shape is scribed or marked on the stainless material, and this line is then gouged out mechanically through the cladding to lay bare the low-carbon steel. It can then be flame cut in the ordinary way.

Recent investigations have, however, resulted in a suitable procedure for flame cutting stainless-clad plate without the necessity for this gouging practice. A primary difference in shop methods is involved, but the elimination of the need for gouging should more than compensate for the alteration in shop work. Essentially, it is recommended that stainless-clad plate be cut from the mild steel side. This means that it is necessary to transfer the layout, or make the layout in reverse on the mild steel side, instead of the stainless side. Keep in mind that the layout on the reverse side of the plate will have to allow for the difference in dimensions caused by any bevel cutting that may be made.

One other important factor is involved. Due to the need for setting the cutting blowpipe nozzle at a slight angle in the direction of cutting, instead of the usual straight up-and-down position, *machine-guided* cutting is limited at this time to straight lines and those shapes wherein the angle of the nozzle can be maintained; unless provision is made to rotate the cutting nozzle

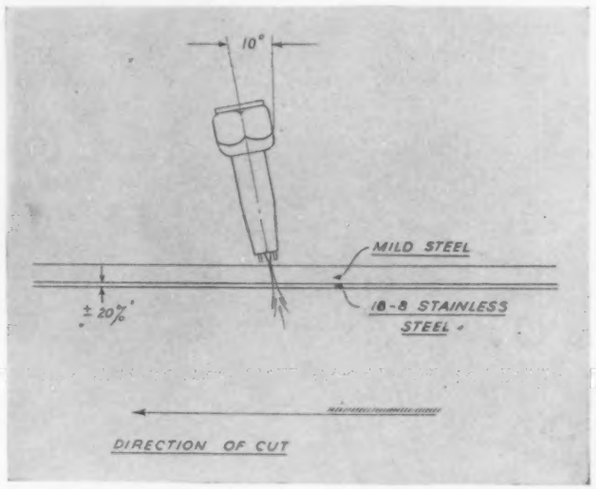
† Development Engineer, The Linde Air Products Co.

so that the lag of the cutting operation always follows and does not at any time precede the leading point of the kerf.

The investigations which were responsible for this new technique not only developed a procedure for cutting stainless- or nickel-clad plate by the oxyacetylene flame, but showed that cuts of an acceptable quality can be made on a production scale. Furthermore, they showed that a standard procedure can be used with all commercial thicknesses of this type of material. The best cutting speeds, oxygen cutting pressures and nozzle sizes to produce good shop cuts can now be easily determined in each particular instance. The procedure can be used either for square cuts or for bevel cuts at 30 or 45 deg. which are necessary for much of the fabrication work.

The Cutting Action

The stainless-clad plate *should be cut from the mild steel side.* The flow of molten mild steel and slag makes possible the clean severing of the stainless steel. Very



Sketch No. 1—Recommended Nozzle Angle for Flame Cutting Stainless-Clad Steel

little of the chemical cutting action, such as is normal for mild steel, takes place on the stainless cladding. The cut in this layer is made almost entirely by the mechanical eroding action of the molten slag, molten steel and the cutting oxygen jet.

This fact requires, in general, the use of a larger size cutting nozzle, a higher cutting oxygen pressure, and a slower cutting speed than are usual for an equivalent thickness of mild carbon steel plate, except possibly on the heavier sections.

Nozzle Angle Important

The cutting blowpipe nozzle should be inclined at an angle of 10 deg. from the vertical (See Sketch No. 1), so that the nozzle and flame point back from the direction of cutting. If the nozzle is held perpendicular to the plate, or points toward the cutting direction, the stainless layer will not cut, but it will deflect the cutting stream so that a cavity is gouged out of the mild steel. If the nozzle points in the correct direction, but with an angle of less than 10 deg. it may produce the same result. An angle of greater than 10 deg. allows the slag to pile up in the cut, and this is detrimental to satisfactory and economical cutting.

A "following" angle of 10 deg. should also be maintained when making bevel cuts.

Machine Cutting Recommendations

For cutting stainless-clad steel, the nozzle sizes, oxygen pressures, speed of cutting and angle of nozzle to work, differ from those for ordinary mild steel flame cutting.

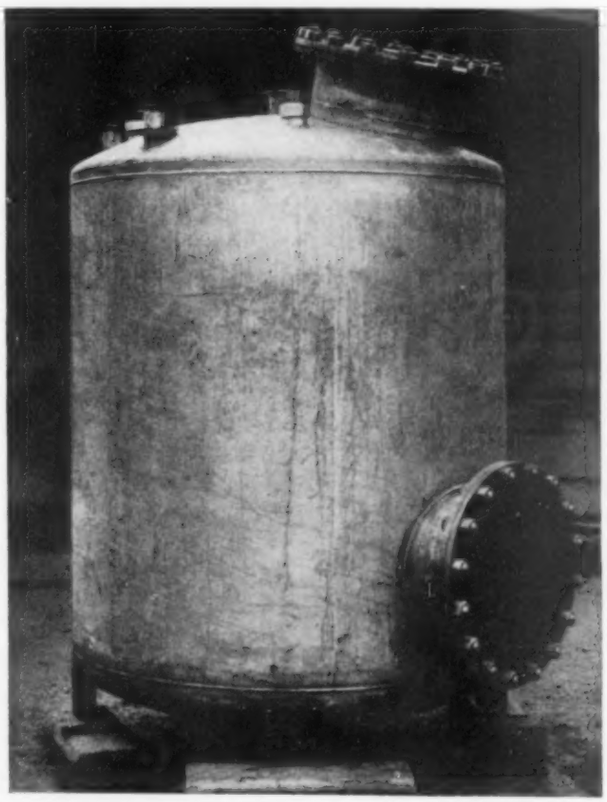
The ordinary plate thicknesses of stainless-clad material formed in regular production routine differ slightly from those ordinarily encountered in mild steel plate. Standard mild steel thicknesses are utilized in making the clad material. The stainless steel layer is added on to the mild plate. The cladding is about 20 per cent of the total plate thickness in the lighter gages, and may be proportionately less as the plate thickness increases through the heavier gages.

A nozzle one size larger than is recommended for the thickness of the mild steel in the plate is recommended as a general rule for working on the lighter gages. It may be found that an increase in oxygen pressure will compensate for this in cutting the heavier gages, and that the same size nozzle as for cutting an equivalent thickness of mild steel can be used. It is well to test the nozzle size with a few practice cuts when new thicknesses are encountered. The most suitable nozzle for a particular job can best be determined in this way.

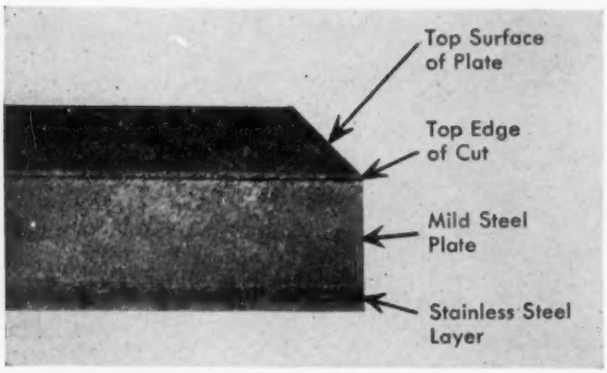
The preheat oxygen and acetylene pressures, if a three-hose blowpipe is used, should be adjusted as recommended by the blowpipe manufacturer for ordinary mild steel of equivalent thickness.

The cutting oxygen pressure for smoothest and most economical results can best be determined by a few trial runs. In general, cutting oxygen pressures 50 to 100 per cent greater than those recommended by the manufacturer of the blowpipe for an equivalent thickness of low-carbon steel have been used with success.

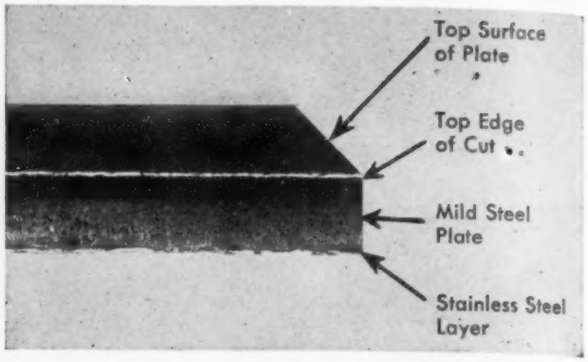
Speed of cutting is much slower. This again is a matter best determined by trial runs.



Flame Cutting Simplifies the Fabrication of Process Equipment of Stainless-Clad Steel Such as This Vessel for Chemical Use



A 45° Bevel Cut on 3/4-Inch Stainless-Clad Steel Plate. Notice the Smoothness of the Face of the Cut



A Square Cut on 3/16-Inch Plate. A Light Grind on the Stainless Layer Edge Has Been Made

As a basis for determining the proper nozzle size, cutting oxygen pressure and cutting speed, the data developed in the investigation on this work are of interest.

Thickness, Inch	Speed, Inch per Min.
5/32	12
3/16	11
1/4	10
3/8	9

The work done here, of course, did not cover the full range of thicknesses ordinarily found in clad materials. Shop work and experimental tests have shown that all commercial thicknesses may be cut.

Hand Cutting Recommendations

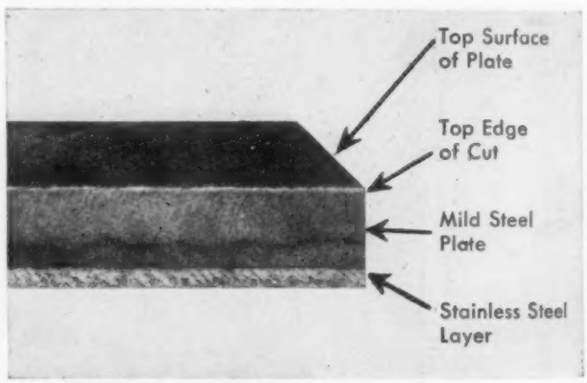
For hand cutting, the same size cutting nozzle should be used as for machine cutting the same thickness of clad steel. The cutting oxygen pressures should be from 5 to 10 lb. per sq. in. greater. The cutting speed should be slightly slower.

The same recommendations with regard to nozzle angle apply. As may be seen from Sketch No. 1, when a cut is started on a square corner, only mild steel will be cut at first. It is essential that this be the case. Otherwise gouging in the mild steel will take place when the cutting stream strikes the stainless steel.

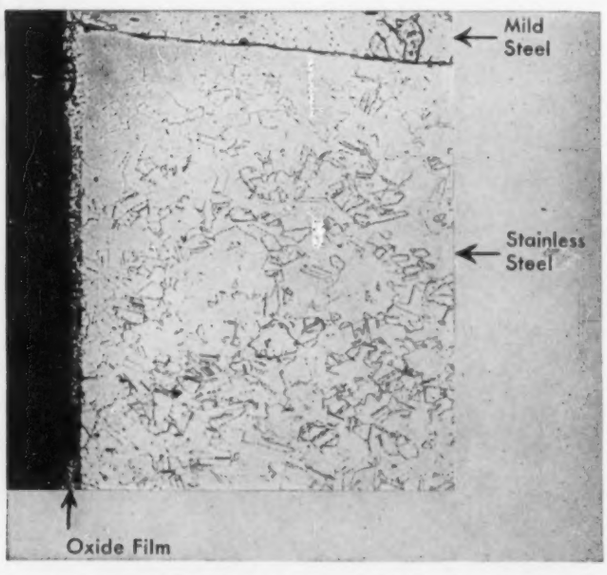
When a cut becomes interrupted and has to be started again, the cutting nozzle must be held at an angle greater than 10 deg. and gradually turned to 10 deg. as the cut proceeds.

In any case do not try to reduce the amount of preheat to improve the cut surface. Gouging of the mild steel and interruption of the cut may result.

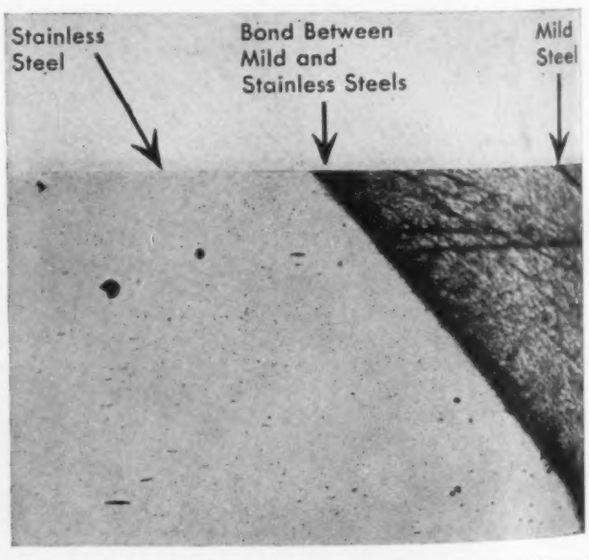
A constant rate of speed and steady movement of the blowpipe are as essential to good hand cutting as they



The 30° Bevel on This Specimen Shows a Good Commercial Quality of Flame Prepared Edge



The Cut Edge of This Specimen Is on the Left. The Bond Runs Horizontally Near the Top. Mild Steel Is Above the Bond, Stainless, Below. The Thin Oxide Film May Be Removed, if Desired, by a Light Grind (X100)



Flame-Cut at 45° Bevel, This Specimen Viewed at 100 Diameters Under the Microscope Shows the Bond (the Black Line) Is Unaltered After Cutting. Mild Steel Is at Top Right; Stainless Is Below and Left of the Bond Line

are to machine cutting. The quality of the cut is entirely dependent upon this.

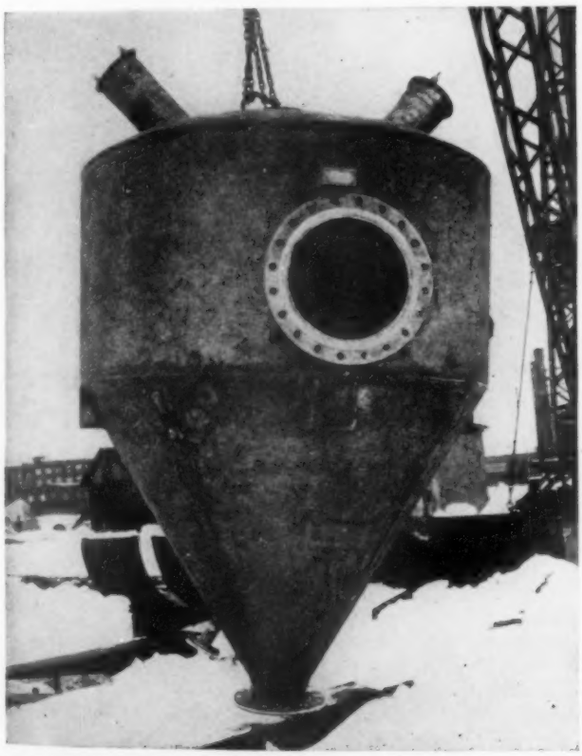
Cleaning the Cut Edge

Slag conditions are quite similar to those present in the cutting of mild steel plate. On square cuts, the slag can be easily removed with a chisel. The cut edge on the stainless steel layer is only slightly less smooth than that obtained on the mild steel. This can be readily smoothed, if desired, with a file or a grinding wheel.

On bevel cuts there is practically no slag on the finished cut, since almost all of it adheres to the scrap. The small amount that does adhere to the finished surface may easily be removed with a scraper. No filing or grinding is necessary on bevel cuts.

Effect of Cutting

Laboratory investigations were made on several samples of flame-cut stainless-clad steels to study certain important physical and chemical qualities of the cut edge.



The "Cone Bottom" Tank Is Typical of Equipment Fabricated of Stainless-Clad Steel

Of these, the first fact determined was whether or not any separation of the bonded metals had occurred during the cutting operations. No separation had taken place in any of the specimens.

Microscopic examination of the edges showed that a slight change in granular structure had occurred in the stainless steel directly adjacent to the flame-cut edges. This condition is attributed to melting and subsequent formation of a light oxide film on the flame-cut edges. It was less noticeable on the square cut edges than on those that had been beveled. The entire effect, however, was so slight as to be easily removed, if desired, by a light grind.

Corrosion Resistance

Another important point studied was the effect of the cutting operation on the resistance to corrosion and intergranular attack of the stainless steel. Until the development, about two years ago, of methods for stabilizing stainless steel, certain service conditions caused a tendency to lower the corrosion resistance of stainless steels by producing a susceptibility to what is known as "intergranular corrosion."

When a stainless steel of the 18 per cent chromium 8 per cent nickel type is heated to within a temperature range of about 500 to 1400° F., the material is susceptible to an intergranular type of corrosion. The use of small percentages of elements such as columbium or titanium in the stainless alloy eliminates the susceptibility to intergranular attack. Steels treated with such elements are known to be "stabilized."

As the stainless steel cladding on these samples was not of the stabilized type, the heat effect of the cutting flame on the corrosion resistance of the stainless layer was somewhat similar to that discussed in the preceding paragraph; and was similar to the effect in the welding of stainless steels which have not been treated with stabilizing elements. The corrosion resistance was lowered, but the amount was not considered excessive; and in most instances no tendency at all toward intergranular corrosion was observed. In order to insure uniformity of results in cases where severe corrosive conditions are encountered, it would seem advisable to use stainless-clad steels in which the stainless layer is of the stabilized type.

No Carbon or Iron Pick-Up

Another phase of this study, important when considering stainless steels, was the extent of carbon pick-up. The carbon content of stainless steel has an important effect on its corrosion resistance. Increase in the carbon content causes a decrease in the ability of the steel to resist corrosion at elevated temperatures such as are frequently encountered in service. "Low carbon" stainless steels, generally specified for high corrosion resistance, usually have a maximum of 0.10 or 0.07 per cent carbon depending on the intended service.

Carbon determinations were made on the edges and center portions of each of the samples. A tendency for the cut edge to *lose carbon* during the cutting operation was observed. The usual expectation would be for it to pick up carbon. The loss of too much carbon might be equally undesirable. In the case of these flame-cut samples, however, there was not sufficient loss of carbon to be considered at all detrimental.

Because of the fact that the stainless layer is bonded to mild steel, the extent of iron pick-up was also of interest. Any appreciable amount of iron pick-up by the stainless cladding might be expected to dilute the alloy and thus cause it to lose some of its corrosion-resistant properties.

It was found that the cut edges did not pick up any appreciable amount of iron.

Nickel-Clad Steel

Field tests have shown that the same procedure can be used in cutting nickel-clad steels. This has been tried at the same time as similar work on stainless-clad steel. The material was $^{3}/_{8}$-inch nickel clad steel with the cladding 20 per cent of the total thickness. A cutting technique exactly similar to that used for the stainless-clad material produced equally satisfactory results.

Rail—Recent Tests and Development*

By F. R. LAYNG†

THE Bessemer and Lake Erie Railroad has installed an interesting welded rail experiment in its southbound track at River Valley, Pennsylvania. This test is one mile in length, a little less than half of which is tangent track, the remainder being a 1° 30′ curve and a compound curve having a maximum curvature of 5° 43′. A portion of the installation is on level grade, part on a 0.65 descending grade south bound and part on two rather long vertical curves.

The traffic consists almost entirely of heavy tonnage freight trains, operating at a maximum speed of 40 miles per hour and an average speed of about 30 miles per hour. One local passenger train per day moves over this track at a maximum speed of 50 miles per hour. At the present time from 8 to 10 tonnage trains per day are handled, the trains containing up to 125 cars. We estimate that the average annual gross tons hauled over the rail will be between 12 and 15 million. Since the track was put in service approximately 18 million gross tons have been moved over the welded rail.

Our standard locomotive is of the Texas type (2-10-4), maximum weight on axle being 75,900 lb., and a large percentage of our equipment consists of 70 and 90-ton capacity cars.

The method of procedure in making the installation was, first, to single-track the line, the northward main being used for movements of both directions. After the existing track had been removed, the old ballast was cut down to sub-grade with a spreader working on the northward track. The new ties, with GEO plates previously attached, were distributed and new rail in 39-foot lengths, 131 lb. A.R.E.A. section, was placed on the ties. About one-quarter inch section of the lower half of the web and and base of the ends of each rail was cut away with a torch to provide a one-half inch gap (except at the head) when the rails were clamped together. The head of the rail and the upper part of the web were then cleaned thoroughly to remove all scale and rust.

The ties are red oak, treated with creosote and prebored before treatment. The tie plates are of the GEO type, secured to the ties with four screw spikes and were placed on the ties at River Valley in advance of being distributed. The track is ballasted with limestone and after it had been thoroughly compacted by use, the entire mile was given a light surface lift and tamped with air tools.

One interesting detail with regard to the construction of the track that gave us some apprehension was our ability to bring it to final line if the clamp bolts on the GEO plates were put down to place. During the construction of the track and during all the preliminary surfacing and lining, the bolts were left partially loose. After we had completed the final lining and within a few hours, all of the bolts were put down to their proper positions. At that time the temperature was from 63 to 65° F. This permitted us to bring the full mile of welded rail to a final line without difficulty.

The welding method adopted is the well known thermit process. This part of the work was supervised and all of the plant necessary for making the welds was furnished by the Metal and Thermit Corporation of New York. Aside from this supervision, all of the labor was performed with company forces, including the preparation of the molds.

Welded Rail, River Valley, Pa.

Most of you understand the thermit process, but for the benefit of those not familiar with it, the following description is given:

Briefly, the thermit welding process consists of bringing the rail ends tightly together, placing a mold around this junction, preheating the rails near the joints, generating superheated liquid steel by means of the thermit reaction, and allowing this steel to run into the mold and to form a collar of deposited metal around the base and the web of the rail. The thermit steel is obtained by igniting in a crucible a quantity of thermit, which is a mixture of iron oxide and aluminum. During the resulting reaction, the iron is set free in the form of a superheated steel at a temperature of 4000 to 5000° F. and drops to the bottom of the crucible. The aluminum unites with the oxygen in the iron oxide to form a light alumina slag which floats on top of the molten metal.

Pressure butt welding in combination with the thermit is one of the well known methods of rail welding. With it a fusion weld of the base and web of the rail with thermit steel is provided, while the head is welded by pressure only. The heating of the head to welding tem-

* Presented before New York Railroad Club.
† Chief Engineer, Bessemer & Lake Erie Railroad Company.

Welded Rail, River Valley, Pa. Placing Molds

perature is brought about by means of the slag which results from the thermit reaction. The molds are so constructed that this slag completely surrounds the head and brings it to welding temperature in a very short time after pouring. When the proper temperature in the head is reached, heavy clamps, which have previously been fastened to the rail, are drawn up, the rail heads are forced together under very high pressure and an adequate butt weld is secured.

Two sets of clamps and crucibles were used simultaneously. Seventeen joints was the average number poured in eight hours. Twenty-four joints was the maximum during the progress of the work during any one day. In all 269 joints were made. The track was put out of service October 7, 1935, welding was started October 10, completed October 29, the grinding was completed November 8 and the track turned over for service on November 9, 1935.

The purpose of this test is to determine:

1. Whether or not the thermit weld will prove satisfactory.
2. To determine what movements take place in long stretches of continuous rail.
3. To determine the stresses in the rail that are encountered in this type of construction.
4. To determine whether or not the GEO type of plate furnishes a fastening sufficiently positive to control the stresses of expansion and contraction due to changes in temperature.
5. To determine whether or not this type of construction offers economies in track maintenance.

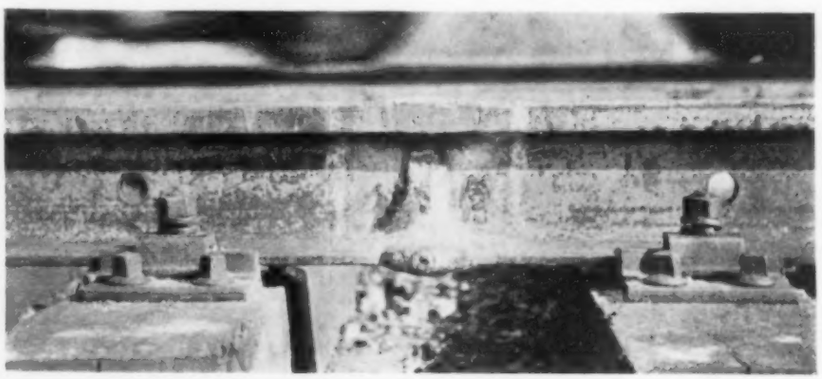
This installation has been in service too short a time to give final answers to the above questions. So far, we have had no broken welds and the running surface of the rail in the area covered by the welds has shown no indication of breaking down. The installation has been through two winters, one quite severe, and one summer during which we had an unusually long period of extremely hot weather. The minimum air temperature recorded was—15° F. while the maximum was 104° F.

As part of the study made during this test, an investigation was conducted to determine the relationship between air temperature and the internal temperature of the rail. To secure data on the internal temperature, a short section of rail was placed on the ties between the rails of the southward track. A hole 1 inch in diameter and $1\frac{1}{2}$ inches deep was drilled into the head of the short section of rail and this was filled with mercury. A thermometer was properly placed in the mercury, and in this way the approximate internal temperature of the rail was measured. Readings were taken every 15 minutes for a period of one week. This study shows that in hot weather the internal temperature of the rail builds up higher than that of the air; for instance, on July 22, 1936, with a maximum air temperature of 104° F., the internal temperature of the rail was 119° F. Tests during periods of cold weather have not yet been run, but we are of the opinion that here the internal temperature will lag behind the air temperature. It is interesting to note that the surface temperature of the rail is, for all practical purposes, very close to the air temperature.

Permanent monuments were set at appropriate locations along the track to record the longitudinal and transverse movements of the rail. Readings are made once a month and records are being kept of such movements as take place. So far, no longitudinal movements of special interest are recorded except at the extreme ends of the installation. Here the rail moves in harmony with changes of temperature—the maximum longitudinal movment covering a range of one inch at the south end, $\frac{3}{4}$ inch is the range at the north end.

The following transverse movements are recorded: At a point 100 feet from the south end $\frac{5}{16}$ inch to the west; near the north end of the compound curve $\frac{3}{16}$ inch to the east; at north end of welded rail $\frac{3}{16}$ inch to the west.

As a whole the track has remained in excellent line and surface and no lining or surfacing has yet been necessary. Naturally the installation has been in too short a time to develop any accurate data as to cost of maintenance. This is particularly true because new material was put in for the whole installation. Should this type of construction prove satisfactory, we shall be able to furnish data as to the maintenance costs.



A Complete Welded Joint Partially Surfaced

Arc Welding Power Supply*

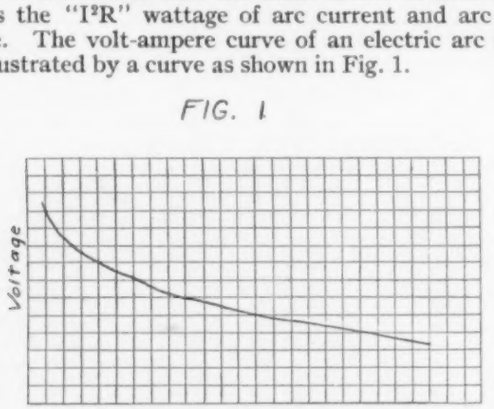
By ROY L. SPAULDING†

THIS paper will present an exposition of the different types and methods used for arc welding power supplies showing the relation between the requirements of the welding arc and the electrical characteristics of the power supply.

The requirements of the welding arc are different depending upon whether a carbon arc, a bare electrode metallic arc, or a heavily coated electrode metallic arc is used. However, given a sufficiently large voltage and current range, a machine which is satisfactory for bare electrode metallic arc welding will perform as a power supply for either the heavily coated electrode metallic arc of the carbon arc. This is brought out by observation of the resistance characteristic of the arc and a study of the phenomena of metal transfer through the arc.

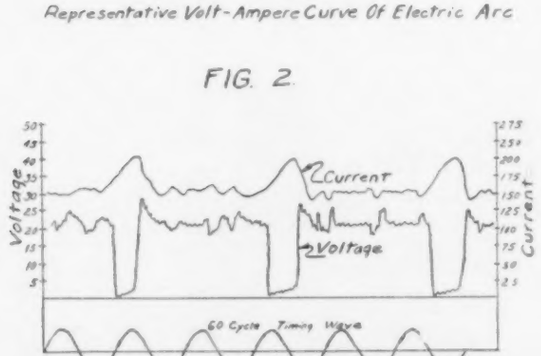
The carbon arc as well as the metallic arc has a negative resistance characteristic. That is, the resistance per unit volume of arc stream decreases with an increase in current. The probable reason for this characteristic is the fact that the ionization in the arc stream is proportional to the temperature which in turn is largely determined by the arc current. Of course the greater the ionization the lower will be the resistance. The connection between arc current and arc temperature is seen when it is recalled that the main source of heat in the arc is the "I^2R" wattage of arc current and arc resistance. The volt-ampere curve of an electric arc might be illustrated by a curve as shown in Fig. 1.

FIG. 1



Representative Volt-Ampere Curve Of Electric Arc

FIG. 2



Representative Oscillogram Of Arc Voltage & Current

From this curve one of the first requirements of an arc welding power supply might be determined. The voltage and current must be in the range as required by the arc and the volt-ampere curve must be of drooping characteristic and of steeper slope than the curve of the arc. Such a combination will produce an arc which under static conditions is stable at any given setting of the power supply controls. As the carbon arc is steady, a power supply giving these volt-ampere characteristics over the proper range is all that is necessary.

Another factor in the resistance of the metallic arc is the transient temperature change, somewhat periodic in nature, and of a frequency of about 1000 cycles a second. In seeking an explanation for this phenomena it would be well to consider the sources of heat in the arc. There are essentially two sources of heat in the metallic arc, one from the electrical energy supplied, the other from chemical reactions on the electrode material as it passes across the arc. The electrical energy accounts for the greatest share of the heat and is distributed such that a plane perpendicular to the arc stream dividing it in two equal lengths would have sixty per cent of the heat on the anode side and forty per cent of the heat on the cathode side. The chemical reactions such as oxidation of iron, carbon and silicon in the filler metal as it passes across the arc probably account for the high frequency variations in arc temperature and in turn arc resistance. This condition is illustrated by the oscillogram (Fig. 2) of arc voltage with a steady current.

The condition of rapidly changing resistance puts another requirement on the metallic arc welding power supply. It must be capable of meeting the almost instantaneous voltage demands of a circuit whose resistance is varying in the frequency of about 1000 cycles per second without allowing the current to vary a large amount. This condition must be met in order to have a steady arc without an excessively heavy current. That is, if this condition were not met, the arc would be extinguished for each increase in resistance.

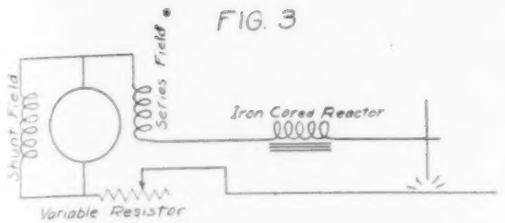
The phenomena of metal transfer through the arc also has an important bearing on the circuit characteristics of the power supply. High-speed motion pictures of the welding arc and oscillograms of arc voltage and arc current as the one above (Fig. 2) indicate that drops of molten metal extend from the electrode to the parent metal thus temporarily short circuiting the arc many times per second. This short circuiting action is shown in the above oscillogram (Fig. 2) by the deep troughs in the voltage curve and the current peaks at the corresponding times. Comparing oscillograms of arc voltage of bare electrode arcs and heavily coated electrode arcs it is seen that the number of short circuits is much greater with the bare electrode. This same fact is brought out by J. L. Larson, who describes his experiments in the October 1936 issue of THE WELDING JOURNAL. He shows that metal is transferred across the shielded arc in small particles $^1/_{1000}$ inch to $^1/_{100}$ inch in diameter and generally without short circuiting.

In order for the arc to function smoothly with this periodic short circuit, the current must increase to its short circuit value without excessive overshoot. When

* Presented at June 2nd Meeting, Montana Section, AMERICAN WELDING SOCIETY.

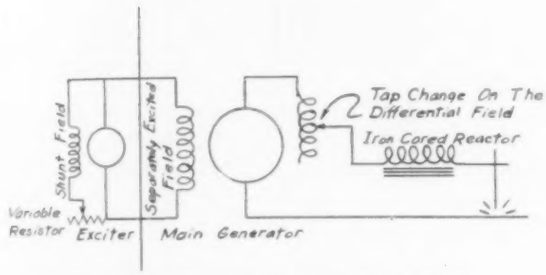
† U. S. Engineers, Fort Peck.

FIG. 3



Schematic Diagram Of A Constant Voltage Generator As Used For An Arc Welding Power Supply

FIG. 4.



Schematic Diagram Of Separately Excited Welding Generator With A Differential Series Field

the short circuit is broken the current must fall to its normal value without shooting below this value. The voltage of course drops to zero during the time of short circuit and must rise almost instantaneously to normal value without excessive overshoot at the time the short circuit is broken. This is another requirement which must be met by an arc welding power supply in order to produce a steady welding arc without excessive heat which would result in burned metal.

Other requirements of an arc welding power supply which should be met or at least approached are as follows: The arc must be easy to strike without sticking. This characteristic usually follows as a result of having small current overshoot on short circuit and quick voltage recovery when the short circuit is broken. The splatter should be at a minimum. This is accomplished by having the volt-ampere curve steep enough so that the short circuit current is limited to about twice average welding current. Also the overshoot of current when the arc is short circuited by the drop of molten metal must be small, otherwise an excessive current during this time will cause a veritable explosion of the metal which of course will cause splatter. Magnetic blow should be minimized. With D.C. machines very little can be done by changing the machine. However, changing the path of the current through the parent metal will usually have a good effect. In A.C. machines, particularly high frequency types, arc blow is not strong enough to be detrimental.

The requirements as outlined above are met by various means. In the days before there was a generator designed specifically for arc welding use, was made of a constant voltage generator with a series inductance and variable resistance. The inductance served to store magnetic energy and thus give a steady current and quick voltage response which is essential to a good welding arc. The variable resistance served to give the necessary drooping characteristic to the volt-ampere curve and also as a means of adjusting arc current and in turn arc heat. The chief disadvantage to this arrangement was the enormous power loss in the resistance when the slope of the volt-ampere curve was made as steep as desirable.

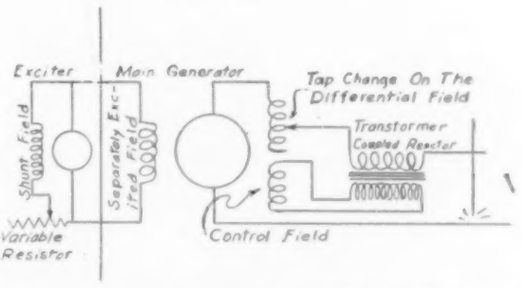
In order to have a more efficient power supply the individual operator differential compound D.C. Welding generator was developed. This machine produced the desirable drooping volt-ampere curve by means of the differential series field. The necessary current control and voltage response was produced by an external iron cored reactor in series with the welding current. Control is effected by changing the resistance of the shunt field or changing the exciter current if the machine happens to be separately excited and by tap changing on the series field, a variable resistance in the welding circuit or by brush shifting. Either one of the first two methods are used for fine adjustment while any one of the last three are used for coarse adjustment. (Fig. 3)

A further development of this type of power supply was the transformer coupled reactor. This system used a transformer instead of a reactor in series with the welding current. The purpose of this method was to reflect variations in the welding current back into the field of the generator such that the voltage built up by these reactions would be in such a direction that it would oppose further change in the current. The effect of this system was to increase the effective inductance of the welding circuit with a decrease in the iron and copper and in turn a decrease in the iron and copper loss. (Fig. 4)

The next development and at present the latest in D.C. machines consists of removing all external resistors and reactors. Control is effected by magnetic means either by brush shifting or by applying a magnetic shunt across the fields. Arc stability is attained by using armature reaction to produce a drooping volt-ampere curve and inherent reactance is used for current stability and voltage response. Inherent reactance is obtained by magnetically interlocking the welding circuit with the field circuit so that changes in the welding current are reflected back to the field in the form of magnetic energy which in turn produces a voltage response. (Fig. 5)

A.C. Arc welding power supplies have also undergone considerable development since they were first used. The single phase, sixty-cycle transformer with tap changing and a series resistance in the welding circuit or a variable inductance in the primary is the most common type today. The chief advantage of the transformer as a power supply is its relative low first cost, upkeep and high efficiency. For the lower current ranges the commercial frequencies of the fifty or sixty cycles do not produce as stable an arc as is desired. This may be explained by noting that there is a considerable time interval during which the current is too low to keep the arc hot. Thus, when small currents are concerned the arc

FIG. 5



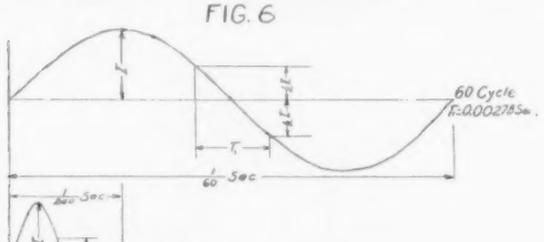
Schematic Diagram Of Separately Excited Welding Generator With A Differential Series Field And Transformer Coupled Reactor

will cool off during this period and either go out or be difficult to maintain. (Fig. 6)

Using a higher frequency A.C. the steepness of the wave is greater and trouble with holding the arc is eliminated. Stability is not so great a problem with the A.C. arc as with the D.C. arc. This might be explained by the fact that the voltage and current automatically drop to zero twice during each cycle and also automatically rise with a rapidity depending on their frequency and final value. This action makes them more independent of arc conditions. Another advantage of high frequency current for arc welding is the absence of magnetic blow. This is probably due to the inertia of the particles comprising the arc stream. That is, being forced to go in one direction by magnetic action, they no sooner start to attain velocity in that direction than the force is reversed giving a sum total of movement due to magnetic blow of near zero.

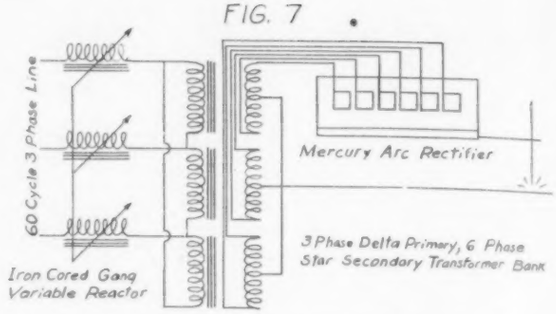
The types of high frequency power supplies which are worthy of mention for use in arc welding are the synchronous generator, the induction generator and the

FIG. 6



Time Interval During Which Current Is Less Than One Half Maximum

FIG. 7


60 Cycle 3 Phase Line
Mercury Arc Rectifier
3 Phase Delta Primary, 6 Phase Star Secondary Transformer Bank
Iron Cored Gang Variable Reactor

Schematic Diagram Of Mercury Arc Rectifier Set As Used For An Arc Welding Power Supply

inductor generator. Of the three mentioned the inductor generator will probably be the most widely used. This would of course be due to its relative simplicity and ease of construction.

Another development of interest in arc welding power supplies which at present is in the experimental stage is the three-phase mercury arc rectifier. This outfit uses a three-phase transformer with a variable choke coil in the primary for control. The choke coil gives the desirable drooping volt-ampere curve as well as a means of control.

In conclusion, I would like to say that there is still room for improvement of arc welding power supplies from the standpoint of ease of manipulation, efficiency, first cost and upkeep. It is difficult to conceive how much improvement in quality of weld metal or speed of depositing it can be made by improving arc welding power supplies. Looking for future development, the field of the high frequency generator appears to be the most promising.

Hard-Faced Circular Saws

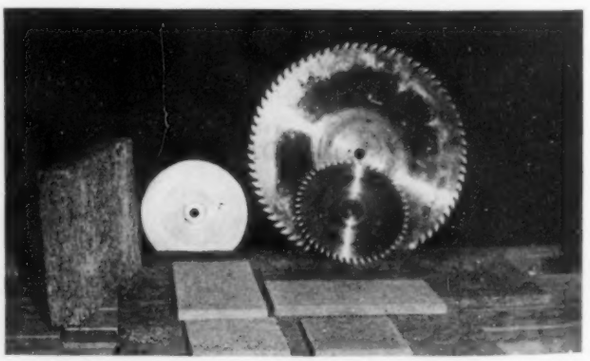
By R. K. KENNEDY†

Abrasion of Sawing Wall Board Necessitates Hard-Facing

A COMPANY using circular saws for cutting wall board standardized on hard-faced saws after trying several ideas and materials to increase the saw life. This particular kind of wall board is composed of shredded wood and magnesite cement. It is very abrasive, and conventional saws for cutting it wear out rapidly. When the saw teeth are hard-faced, however, the life is increased about eight to ten times.

Saws 32 inches in diameter are used to cut to length the hot board coming from ovens at 600 to 800° F. Ordinary saws lasted only about an hour, but hard-faced saws now last a whole day. Twelve to sixteen-inch saws trimming the edges, cutting in almost solid magnesite cement, had to be changed every half hour, whereas hard-faced saws now work for five hours between changes. The 12 to 16-inch finishing saws had a life of one hour, but hard-facing increased this life to ten hours.

The hard-facing operation is simple. The saw teeth, spaced $^5/_8$ inch apart, are first ground back $^1/_8$ inch on the face for one-half the depth of the tooth. The hard surfacing welding rod is then flowed onto the prepared



Circular Saws Hard-Faced with Wear Resisting Alloy. They Cut Off and Shape Abrasive Magnesite Wall Board Material

recesses by the oxyacetylene process. For a 16-inch diameter saw, approximately $^1/_4$ lb. of hard-facing material is required, and the welding operation takes 2 hours. When the hard-facing is completed, the teeth are hand ground to their approximate size and shape in an hour. They are finish ground on a circular saw grinding machine in the same time as required for ordinary saws.

Teeth hard-faced in this way have greatly prolonged the cutting life of the saws and helped to keep production at a steady rate. The success and economy of the hard-facing application have made it standard practice in the maintenance of all saws at this plant.

† General Publicity Department, Haynes Stellite Co.

Resistance Welding Improved by Thyratron Control*

Spot and Seam Welding—Variables to Be Controlled—Influence of Timing on Heat Production—Short Timing—Nonsynchronous Controls—Advantages of Thyratron Control—Application

By WARREN C. HUTCHINS†

RESISTANCE welding, like other types of welding, must be properly controlled if it is to be dependable. When so controlled, it furnishes not only a reliable but a quick and low-cost means of fabricating assemblies from sheet metal or from various other forms of metals and alloys. The term resistance welding covers both spot and seam welding.

To make a spot weld, the parts to be welded together are clamped between two electrodes, as shown in Fig. 1, and then current of high density is passed for a brief interval through the electrodes and the work. The impedance of the current path is so low that a welding potential of 12 volts or less is usually sufficient for the welding operation. The welding current at this low voltage is ordinarily obtained from a single-turn secondary of a transformer, the primary of which is connected to an alternating power supply. The reactance of this transformer should be kept as low as can be justified economically.

For high-speed welding it is essential that one electrode move rapidly from the open position to the closed position and back to the open position. To insure long life of the electrodes and minimum deformation of the parts being welded, the electrodes when coming in contact with the work must not strike it hard. A motor-driven cam-operated electrode permits smooth high-speed operation. An adjustable compression spring located between the electrodes and the cam permits adjustment of the pressure. The main disadvantage of this mechanism is the lack of a simple method of determining the pressures that will result from different spring settings; furthermore, a slight variation in the thickness of the work will cause a difference in the applied pressure.

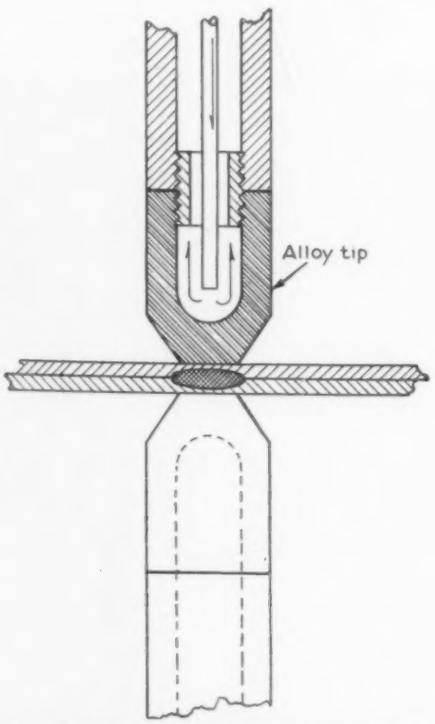


Fig. 1—Water-Cooled Spot Welder Electrodes with Removable Alloy Tips Showing Cross-Sectional View of Heated Area in Making a Spot Weld

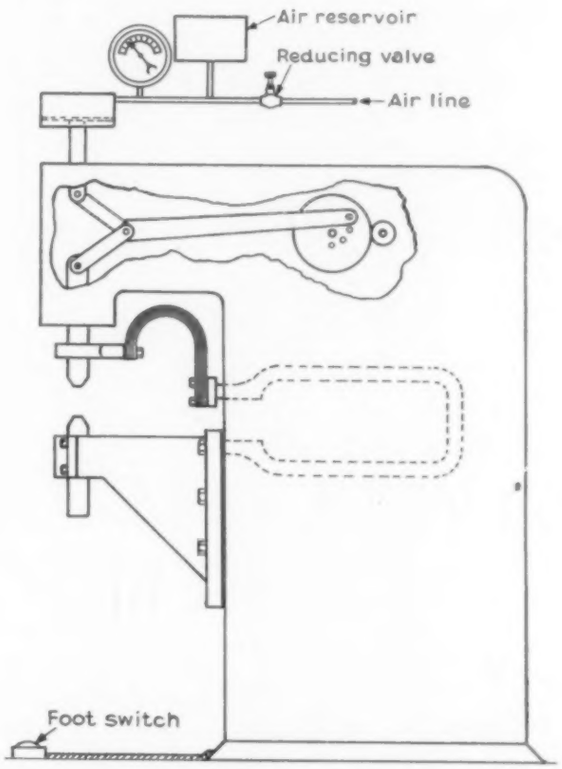


Fig. 2—Modern Spot Welder with High-Speed Mechanical Movement and Air Cushion with Pressure Gage and Reducing Valve to Facilitate Pressure Adjustment

For ease of adjusting the pressure of the electrodes on the work, an air-piston-operated machine is excellent. An air gage calibrated directly in total pounds pressure of the electrodes on the work and a reducing valve to adjust the pressure permit the operator to make adjustments quickly and accurately. The principal disadvantage of the air-operated machine is the slowness with which the air must be admitted to the cylinder in order to prevent the work being damaged by impact of the electrodes. The resulting low speed limits production.

A modern spot-welding machine which embodies the advantages of both the cam and the air-operated machines, without the disadvantages of either, is shown in Fig. 2. In this machine a foot switch energizes a clutch that causes a motor to drive the crank through one revo-

* Reprinted from *General Electric Review*.
† Industrial Department, General Electric Company.

lution at constant speed. The crank operates a toggle mechanism for lowering and lifting the upper electrode. With this particular linkage, the upper electrode travels relatively fast until it comes close to the work (which is placed between the upper and lower electrodes) and then, with a minimum of impact, applies pressure. As the toggle straightens, the upper electrode exerts on the work a pressure which corresponds to that in the air cylinder, or air cushion, plus the weight of the parts. At the instant full pressure is on the work, an auxiliary switch closes to initiate an automatic timer. The automatic timer then applies the welding current for a brief interval (usually 2 to 10 cycles of the 60-cycle power supply). After the current flow has been stopped, the electrodes lift from the work, a weld has been made and the machine is ready for another weld.

In Fig. 3 is shown a cross-section micrograph of spot welding that joins together two sheets of stainless steel, each 0.037 inch thick. The contact-end diameter of each electrode was $1/4$ inch, the total pressure 250 lb., the current 26,000 amps., the current density more than 400,000 amps. per sq. in. and the duration of current flow $1/60$ of a second (one cycle of the 60-cycle supply). With a typical spot-welding machine, having 0.3 power factor, 7200 such welds can be made with a consumption of one kilowatt-hour in the circuit of the welder.

Ordinary spot-welding procedure can be readily applied to joining together two sheets of metal where the thickness of each is not more than $3/16$ inch. Thicker sheets can be welded but this is not practical with the conventional single impulse of power because of the high electrode cost. One electrode may last only five or ten welds when welding two $1/2$-inch plates together.

A recent welding development, known as interrupted spot welding, makes possible the spot welding of plates $1/2$ inch thick or more (Fig. 4) without excessive electrode cost. It can also be advantageously used when welding parts only $3/16$ inch thick. The welding is done by rapidly interrupting the current while the electrodes remain clamped on the work. Because the electrodes are water cooled, they keep the outer surfaces of the work cool while the temperature at the contacting surfaces of the parts being welded builds up to a welding temperature. For example, when welding two $1/2$-inch plates, eight current impulses are supplied to the welder, the timing for each impulse being ten cycles and the "off" time between impulses being eight cycles (1 cycle = $1/60$ sec.).

A seam-welding machine is similar to a spot-welding machine except that roller or wheel-type electrodes are used. As shown in Fig. 5, these electrodes rotate in contact with the work, while four streams of water flood the work and electrodes to keep them cool. As the work progresses, current is applied intermittently at such intervals that the overlapping series of spot welds produced results in a gas-tight seam weld (Fig. 6).

If current is applied constantly (instead of intermittently) a lower voltage will produce sufficient heat, but

Fig. 3—Photomicrograph of a Spot Weld on Two Thicknesses of 0.037-Inch Annealed Stainless Steel; Cross Section Magnified 35 Diameters

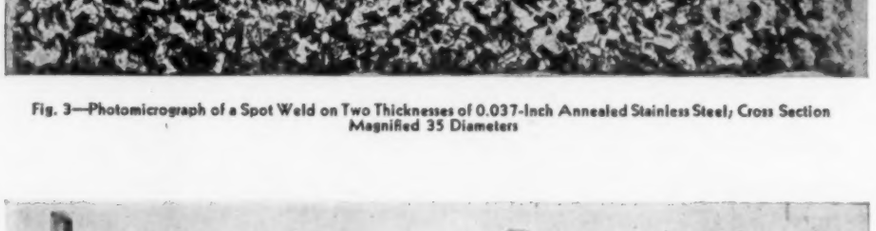


Fig. 4—Specimens Showing Application of Interrupted-Spot-Welding Method

(1) $1/2$-inch brass
(2) $1/4$-inch to $3/4$- and 2-inch steel plate
(3) $1/4$-inch brass
(4) $1/2$-inch steel plate
(5) One-inch plate
(6) $1/4$-inch to 2-inch steel plate
(7) Steel plate

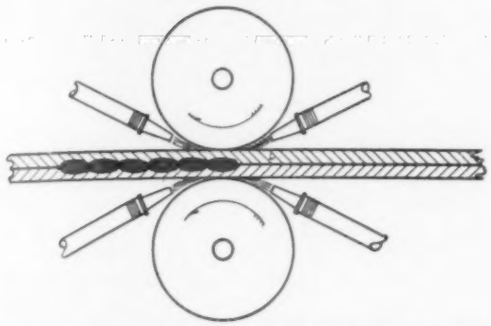


Fig. 5—Seam Welder Electrodes Showing Method of Water Cooling with Four Jets. The Interrupted Current Supply Produces the Equivalent of Overlapping Spot Welds

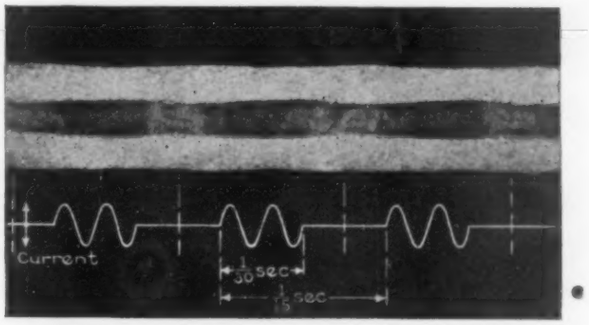


Fig. 6—Photomicrograph of Thyratron-Controlled Seam Welding in Light Material, with Two Cycles "On" and Two Cycles "Off" Showing Also the Equivalent of an Oscillograph Tracing of the Current

as the work progresses heat will travel ahead of the rolls and preheat the metal. After several inches have been welded, the metal just ahead of the rolls will reach a plastic temperature and usually permit the electrodes to sink in, with the result that the product is spoiled. Also, it is believed that a large number of rejects, when using the continuous method of current application, are caused by high-resistance spots on the surface of the work forcing the current to pass mainly back through that part already welded—resulting in no weld at the high-resistance spots. When high temperature travels ahead of the rolls, it oxidizes the surface of the parts to be welded and produces high-resistance spots. However, for some special applications, welding is done without interruption of the current; but the quality of the weld is usually inferior and not gas tight.

By interrupting the current (allowing it to flow approximately 50 per cent of the time), the impulses of current require higher voltage, break down the high-resistance spots, and result in the equivalent of overlapping spot welds. By adjusting the interruption of the current, the spots may be spaced at any desired intervals.

Usually, the metals which have relatively high electrical resistance (such as steel) are more easily resistance welded than those having low resistance (such as aluminum). However, the spot and seam welding of metals which have very low resistance, particularly the high strength aluminum alloys, have been made thoroughly practical by the use of thyratron control equipment, for this equipment inherently possesses all the characteristics necessary for precision control. It has also improved the quality of spot and seam welds that can be made when fabricating the more readily weldable metals, even though the welding speed may be double or triple that with earlier methods of control.

The following are the variables which must be accurately controlled to obtain high-quality welds:

(1) Electrode dimensions, material, contact surface, cooling and pressure work
(2) Surface and character of metal to be welded
(3) Value of current
(4) Character of current wave for each weld
(5) Timing of current for each weld.

The variables listed as items (4) and (5) can be maintained constant only through the use of precise control and for this reason are given special consideration in this article.

Heat for Welding

The flow of electric current through a body which offers electric resistance will generate heat, and the amount of the heat at the weld will be proportional to I^2Rt, where:

(1) I^2 is the square of the current. The formula I^2Rt holds true not only when I represents the effective value of the current over a period of time, but also when it represents the instantaneous values of current. *For the latter reason, the character of the current wave is of prime importance.*

(2) R is the sum of the resistance of the parts being welded and the contact resistance between them. These constitute the highest resistance in the secondary of a welder, for the electrodes are made of a material which minimizes the resistance between the electrodes and the work and the resistance of the remainder of the circuit is negligible.

(3) t is the length of time the current is permitted to flow.

The Welding Circuit

The necessary mechanical form of a welding-machine throat is such as to introduce a comparatively high inductance in the secondary circuit of the transformer. The result is that the secondary current of the trans-

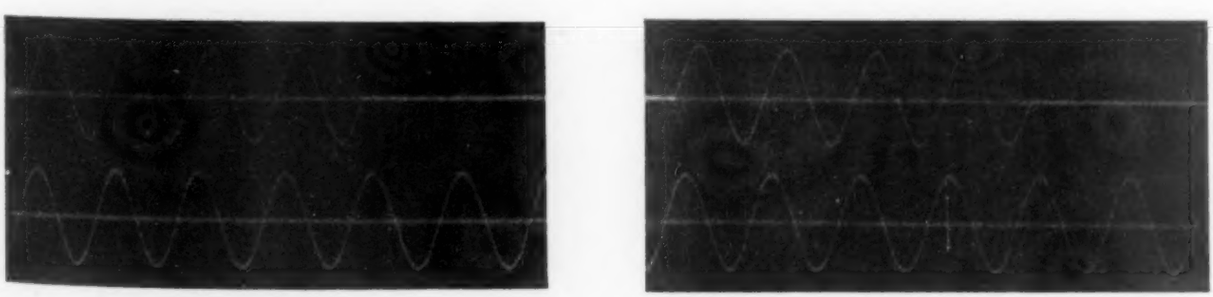


Fig. 7—Oscillograms Showing That Current Variation Caused by Changes of Resistance Between Welder Electrodes Is Negligible. The Upper Trace Shows Primary Current and the Lower Trace Primary Voltage
(*Left*) Welding two Sheets (*Right*) Welding four sheets

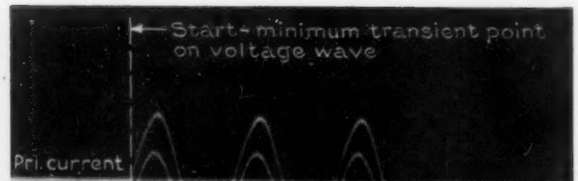


Fig. 8—Oscillogram of the Line Voltage and the Currents in the Welder Transformer When Current Flow Is Started at the Minimum-Transient Point by Synchronous Thyratron Control

Fig. 9—Oscillogram Made When Current Is Started at Zero Point on Voltage Wave. To Be Compared with Fig. 8

former is limited mainly by the inductance of the secondary circuit rather than by the resistance which the work introduces between the welder electrodes. The primary current has the same limitation, if the possibility of saturation of the transformer iron is neglected.

These relationships may be proved conclusively by first measuring the current demand of a conventional spot welder (24- to 30-inch throat) when making a normal weld and then measuring the current demand with several thicknesses of work between the electrodes. The variation in current demand by a welder under these conditions (Fig. 7) will be very slight—usually 5 per cent or less. Another proof that resistance ordinarily plays but a small part in limiting the current flow is given by the fact that the welder has a low power factor (approximately 0.3, which means that the current lags the voltage by approximately 72 deg.—the power-factor angle of the load).

In such a highly reactive circuit as the secondary of a resistance welder, the value of current that flows immediately after the circuit is closed depends largely on the point on the voltage wave at which the circuit is closed, all other factors being the same. If the circuit is closed at a point on the *voltage* wave corresponding to *zero current* (Fig. 8), the current during the first half cycle will be practically the same as the sustained current throughout the welding operation. This means that the circuit is closed at *the minimum-transient point* on the voltage wave.

If the circuit is closed at the zero point on the *voltage* wave (Fig. 9), instead of the *minimum-transient point*, the current during the first half cycle will reach a greater peak value. This is a transient condition and the peak value of the current diminishes as the current flow continues.

Thus, since heating is proportional to the square of the current, the weld will receive a different amount of heat in a given time for each different point of starting on the voltage wave. With relatively long timing, this variable is of little importance; however, for high quality and consistent welding with short timing, this variable must be eliminated.

When the primary circuit is closed at the zero point on the voltage wave, the iron in a transformer of normal design will reach saturation before the end of the first half cycle. The primary current will then be limited mainly by the resistance of the primary circuit, and may reach a value several times greater than normal. The resulting transient may cause serious flicker of lamps on the same circuit because of the voltage dip under this heavy load, yet the heat at the weld may actually be less than in the case where the transient is eliminated and the peak value of the primary current is reduced.

There is a practical limit to the value of current which can be passed through the work that is being welded. The maximum limit may be 400,000 amps. per sq. in. or even more, depending upon the resistance of the metal being welded, the pressure of the electrodes on the work, and other factors which affect the heat developed between the welded electrodes. Excessively high currents would eventually cause burning or overheating of the electrodes and welded parts. "Spitting" or "flashing," which occurs at the contact point of the electrode and the metal that is being welded, is usually the result of surface heating and the squeezing out of molten or very hot metal by the pressure of the electrodes on the work. The use of lower current values makes this spitting or flashing less likely to occur. The use of lower current necessitates an increase in time of current flow, which may result in a less desirable weld. The maximum practical root-mean-square current applicable during the weld, and consequently the shortest time of current flow, can be obtained only when there is no transient. This is accomplished by starting the current flow at the minimum transient point on the voltage wave.

Short Timing

For those welding applications where heat treatment need be given no consideration, there are many advantages to be gained from the use of *accurate* short timing—$^1/_2$ cycle to 10 cycles—all of which are largely the result of proper heat control during these very brief intervals. If all of the welding heat is applied during a very brief interval, the heat is confined—there being insufficient time for it to be conducted through the metal adjoining the weld—thus other portions of the material are not raised to a fusing temperature. Hence, even with considerable variation of other conditions affecting the welds, with accurate short timing the metal raised to a fusing temperature extends only part of the distance to the surface of the work, leaving a bridge of unfused metal on each of the outer surfaces.

The control of heat by this method is so flexible and precise that when welding together two pieces of sheet metal each 0.010 inches thick it can be adjusted to fuse the metal half way through each sheet; that is, in each sheet a portion only 0.005 inches thick is fused (to a corresponding portion of the other sheet) and the remaining 0.005-inch portion is left as a bridge of solid unaffected metal.

In addition to the advantage of consistently producing strong welds, accurate short timing:

(1) Reduces to a minimum the faulty welds caused by variations in commercially available sheet metal. Slight changes in contact resistance will cause only a small change in the amount of metal fused, for with short timing the metal heated to a welding temperature does not extend beyond the location where it is needed.

(2) Minimizes oxidation at the surface of the work. The metal which is exposed to the air is maintained at a comparatively low temperature, because the metal that is raised to a fusing temperature is confined well below the two outer surfaces of the parts that are being welded.

(3) Reduces to a minimum the deformation of the surface of the work caused by the electrodes. The bridge of cool metal—a result of short timing—supports the electrodes and therefore minimizes the indentation of the surfaces.

(4) Assures longer electrode life. Reduced temperature of the metal next to the electrodes minimizes the heating of the electrodes and permits advantageous use of hard alloy electrodes.

(5) Permits faster welding. The actual welding operation takes less time.

(6) Broadens the application of welding equipment. Short durations of current flow when coupled with precise timing permit the successful welding of several alloys otherwise difficult, if not impossible, to weld—for instance, high-carbon stainless steel (18–8) and the high-strength aluminum alloys—and the welding of molybdenum to tungsten, etc.

All of these significant advantages to be gained from accurate short timing can be realized only by the use of a precisely timed control.

Mechanical and Other Types of Non-Synchronous Controls

For Spot Welding and Projection Welding

Magnetic contactors controlled by limit switches, ordinary electronic-tube timers or motor timers have no tendency to close the circuit at the same point on the voltage wave for each weld, because they are not synchronous in operation. If the current thus starts to flow at different points with reference to the voltage wave, welds would receive different amounts of heat (because of transient effects) even though the length of timing were exactly the same for each weld. Moreover, with these nonsynchronous timers the length of timing is not exactly the same for each weld because the devices have inherent operating variations that may cause timing variations of plus or minus $^1/_2$ cycle or more. It was shown in the foregoing formula (I^2Rt) that the heat for each weld varies not only as the square of the instantaneous values of the current but also directly as the time duration of the current flow. Therefore, for consistently high-quality welds it is essential that the time be exactly the same and that the current start flowing at the same point on the voltage wave for each weld.

In some applications it has been found that a variation of the starting point for each weld, relative to the voltage wave will cause a greater variation in the quality of the welding than a variation of one half cycle in the time. However, both of these factors are of prime importance. With nonsynchronous control it is usually necessary to lengthen the time during which current is permitted to flow, so that the variations in heating effect due to the inherent variables of such control devices are reduced to a small percentage of the total heat. This means a sacrifice of the many advantages to be gained by short timing.

It is impractical, if not impossible, to build magnetic or mechanical devices which will consistently close at the minimum transient point on the voltage wave for each weld, and open this high-current circuit after exactly the desired number of cycles of conduction have passed. Although control units have been made using a synchronous-motor-driven switch with certain adjustable elements to minimize arcing when the circuit is opened, it is impractical with these devices to obtain exact control of the point at which the circuit is closed. Moreover, it is considered impractical to make this point variable. Mechanical devices for this purpose are noisy and require frequent adjustment and servicing because of the rapid wear of the moving elements and the pitting of the current-interrupting parts. A change of timing is not readily accomplished because it necessitates a change of gear ratios and the making of other adjustments.

Another scheme of control utilizes circuits that are intended to cause the welding current to flow for a time that is inversely proportional to the amount of the current, the idea being to compensate for variations in the resistance between the welder electrodes. However, because the current varies only a few per cent with more than 100 per cent change in resistance, the complications of such a control are not warranted and, furthermore, if the control is to function as a compensator, the required relaying operations permit welding in no shorter time than 12 to 15 cycles, and thereby the advantages of short timing are sacrificed.

For Seam Welding

To assure high-quality and consistent seam welding at the speeds demanded in modern production, it is necessary to interrupt accurately the current supply to the welding machine in order that overlapping spot welds be produced as the work progresses through the machine.

Experience shows that to make a continuous gas-tight weld, the interrupting speed should usually have such a relation to the linear speed of the work as to produce from 10 to 14 current interruptions per inch, depending on the thickness and characteristics of the metal. Mechanical interrupters are usually limited to speeds of 300 or 400 interruptions per minute. (Speeds of 500 or more are sometimes attempted, but the quality of the work is poor and the number of rejects large.) The maintenance cost of a mechanical interrupter at these speeds is high, and the frequent shutdowns necessary for repair and adjustment are costly. Also, this type of interrupter creates excessive noise—similar to that of a riveting hammer—and for this reason it is objectionable in any plant.

With 12 interruptions of current per inch of weld and 400 interruptions per minute, the maximum speed at which this control can weld a continuous seam is about 35 inches per minute. While mechanical interrupters do make possible a quality of welding which is better than that obtainable with the noninterrupted method of seam welding, a welding machine which is mechanically controlled cannot be expected to produce the best quality of work because as previously pointed out:

(1) Any variation in the starting point with relation to the voltage wave will cause a different amount of heat for each weld.

(2) If the interrupter should for a time consistently start to pass current at the same point on the wave for each conducting interval, and if this point should not correspond to the *minimum transient point*, or if it should start with the same polarity for each interval—for instance, on the positive wave—and pass current for an odd number of half cycles, a direct-current component will result which, within a few conducting inter-

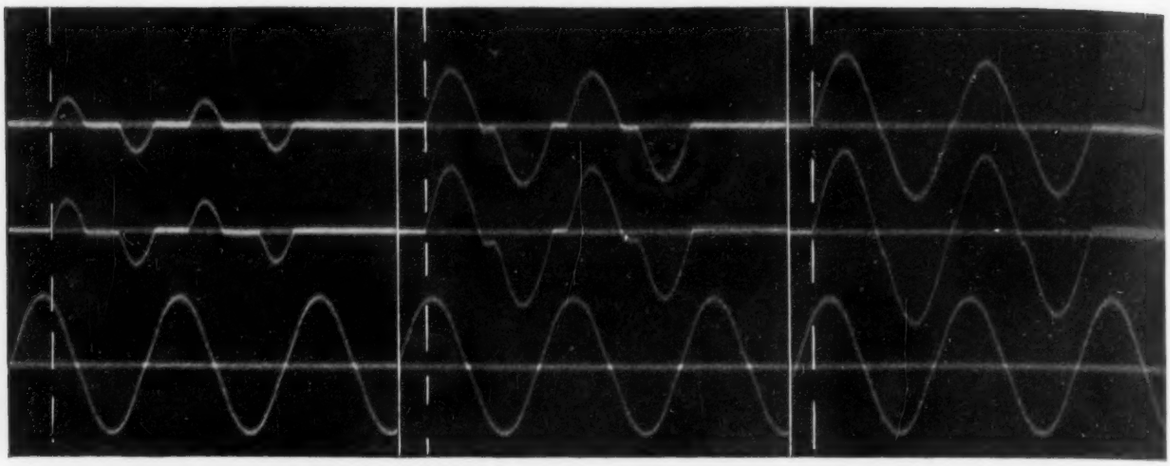


Fig. 10—Oscillograms of Current in Welder When Using Phase-Shift Method of Heat Control Made Possible by Thyratron Welding Controls. Top Curves Are Primary Current, Middle Curves Secondary Current and Bottom Curves Line Voltage
(Left) Low heat (appox. 8%) (Center) Moderate heat (approx. 55%) (Right) Maximum heat (100%)

Table I—Welding Used in Fabrication of Refrigerator Parts

		Seam Welding (per Unit)						Spot Welding (per Unit)		Per Cent Rejects in Several Hundred Thousand Units; Less Than
		Gas-Tight			Intermittent					
Part	Material	Timing (Cycles)	Length (In.)	Speed (In. Per Min.)	Timing (Cycles)	Length (In.)	Speed (In. Per Min.)	Timing (Cycles)	No. of Welds	
Condenser	Mild steel (0.032 in.)	2 "on" 1 "off"	900	100						0.9%
Evaporator	18–8 Stainless steel (0.025 in.)	2 "on" 2 "off"	72	72	4 "on" 4 "off"	300	108	2	70	0.1%

vals, will partially saturate the welder transformer. The result will be a large current increase in the primary of the welder transformer, yet a reduction of current on the secondary, thereby causing a poor weld. If the interrupting device then starts closing at the minimum-transient point on the voltage wave, the welding will become satisfactory but will continue so only as long as the interrupting device continues to close at the minimum-transient point. Such change from bad to good to bad welding may repeat several times a minute, resulting in welds which leak and which must be repaired. Furthermore, the excessive currents in the primary of the welder may cause the transformer to overheat, thereby limiting its speed or capacity or possibly causing the transformer to burn out.

Motor-driven interrupters have essentially a fixed timing ratio. Although by means of gear changes they can be made to operate at different speeds, these speeds are limited to a very few unless many gear ratios are provided. To change the ratio of "on" to "off," a different cam must be used. The production time lost in making such changes is costly.

Thyratron Control

By the use of thyratron tubes in suitable synchronous circuits, engineers have perfected accurate synchronous timing controls that work in conjunction with thyratron power tubes or ignitron power-tubes[1] to control the power supplied to resistance-welding machines. These controls have been applied to hundreds of resistance welding machines—spot, projection and seam welders. With this type of control the current starts to flow at exactly the same point on the voltage wave for each weld, and stops at the zero point on the current wave after the passage of the number of cycles for which the time adjustment was set. The accurate timing and uniform rate of heating thus realized assure consistency of welds. The timing can be easily changed from one setting to another by dial adjustment.

There are two general types of thyratron controls:

(1) Those using a thyratron synchronous timing circuit and ignitron power tubes, in which these ignitron power tubes control directly the primary current to the welder. This type of control is best suited for controlling spot or projection welders, or other welding machines that require a relatively high peak current and a low average current—that is, where the duty cycle is of a low value, such as 5 to 25 per cent.

(2) Those using a thyratron synchronous timing circuit and large thyratron power tubes which work in conjunction with a separately mounted series transformer. This type of control is particularly well suited to seam or spot welding, and to other welding applications where the duty cycle is of a relatively high value, such as 40 to 80 per cent. The inclusion of the series transformer permits the use of relatively inexpensive high-voltage thyratron power tubes, which have a low peak and low average current capacity, to control welding machines which demand several hundred kva on a high duty cycle.

Several different thyratron timing circuits have been designed to fulfill the varied requirements of resistance welding. The simplest, most dependable and least expensive of these timing circuits are those which are adjustable in one-cycle steps. Usually, one-cycle steps of

[1] "Sealed-off Ignitrons for Resistance Welding," by D. Packard and J. H. Hutchings, *General Electric Review*, vol. 40, No. 2, February 1937, pp. 93–97.

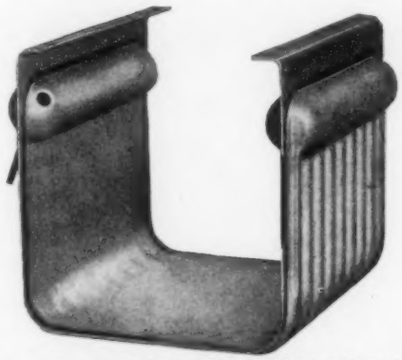


Fig. 11—Refrigerator Evaporator After Being Spot Welded and Seam Welded and the Forming Operation Completed

time adjustment are sufficient for industrial applications of resistance welding, where the current is varied by using different taps (or heat points) on the welder transformer or autotransformer.

However, for greater flexibility there has been produced a control equipment that permits adjustment of the welding time in half-cycle steps. This type of control is of value mainly on a low-frequency power supply (or with 60-cycle power supply when fabricating aluminum alloys). With a 25-cycle supply, for example, one-half cycle steps are comparable to one-cycle steps with a 60-cycle supply. This control, however, is available for frequencies from 25 to 60 cycles.

Still another modification of the timing circuit makes possible the adjusting of the effective value of the current supplied to the welding machine. This heat control is accomplished by means of a phase-shift change whereby each power tube is made to pass current only for that fraction of each half cycle (Fig. 10) that is required to give the proper amount of heat for the welding operation. For maximum current (or heat), the tubes conduct the alternating current without interruption for the complete welding time. For a reduced value of current (or heat), the control is so adjusted that each power tube will pass current for only a fraction of each half cycle, thereby reducing the effective value of the current. By the use of this stepless method of control, vernier current adjustments can be made between the steps normally provided on the autotransformer or the welder transformer. In certain cases, the autotransformer or taps on the welder transformer may be eliminated.

A combination spot and seam welder control using water-cooled ignition power tubes is also available. In addition to the aforementioned time adjustment in half-cycle steps and heat control by the phase-shift method, each accurately timed current flow starts with the same polarity (unipolar starting) or opposite polarity (antipolar starting) depending upon the position of a snap switch provided to permit the selection of the mode of starting. Mounted on the dead-front time-adjusting panel is an oscillographic type of inkless cycle recorder which is used to check the calibration of the time adjusters and which may be used to make a permanent record of selected spot and seam welds. This panel is particularly suitable for welding aluminum, for high-speed seam welding of mild steel, for developmental welding laboratories and for educational purposes. When it is adjusted for one cycle "on" and $^1/_2$ cycle "off," mild steel sheets can be seam welded together (gas-tight seam) at a speed of 240 inch per minute.

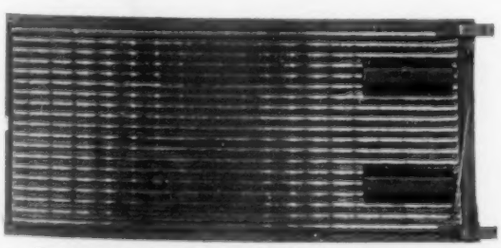


Fig. 12—Refrigerator Condenser Fabricated by Seam Welding

A thyratron control has been especially designed for the new interrupted-spot-welding method referred to earlier in this article. It has three main adjustments:

(1) Number of impulses (from one to approximately 15).

(2) Time of current flow for each impulse (one to 30 cycles).

(3) Welding cycle, which is the sum of the "on" time, and the "off" time (two to 60 cycles).

The electronic tubes with which these thyratron welder controls are initially equipped are furnished by the manufacturer on a liberal guarantee policy. In effect, this policy assures the user that the tube cost per month will not exceed a certain maximum sum when the tubes are used within the specified ratings.

Applications of Thyratron Control

Thyratron control of resistance welding has made a place for itself in industries where high-speed continuous operation is required and where difficult welding jobs are encountered.

Some of the more significant applications of this type of control have been made in the automotive industry. In the Detroit territory, more than 15 of these controls are used for the seam-welding of gasoline tanks which are made of terne-plate. Previous to the use of thyratron control, the speed of this operation was 45 inch per min. Now it is more than 125 inch per min., the number of rejects is decreased and quiet operation is provided.

Another interesting application of thyratron control is found in the production of refrigerator evaporators and condensers (Figs. 11 and 12) fabricated from thin sheets of 18–8 stainless steel and mild steel, respectively, in large quantities by seam and spot welding. Table I gives welding data for certain types of these units.

In the construction of the evaporator unit, the two pieces of metal sheet that form the unit are pressed to shape, with deep corrugations and headers for conducting the refrigerant. This drawing operation is followed by annealing and pickling. The two pieces thus formed are spot-welded together to provide strength in restricted areas, welded around the outer edges with gas-tight seam welding (Fig. 13) and strengthened between the conducting channels with intermittent seam welding. Thus a gas-tight unit is formed. After being bent to its final shape, each unit is tested under water with air pressure. In the plant where these refrigerators are made, 21,000 consecutive units containing 1,250,000 spot welds, over 1,400,000 inches (22 miles) of gas-tight seam welding, and 6,000,000 inches (94 miles) of intermittent seam welding have been produced, and not a single unit has been rejected because of faulty welding.

Other outstanding examples of applications in which thyratron control has broadened the possibilities of welding (Fig. 14) include:

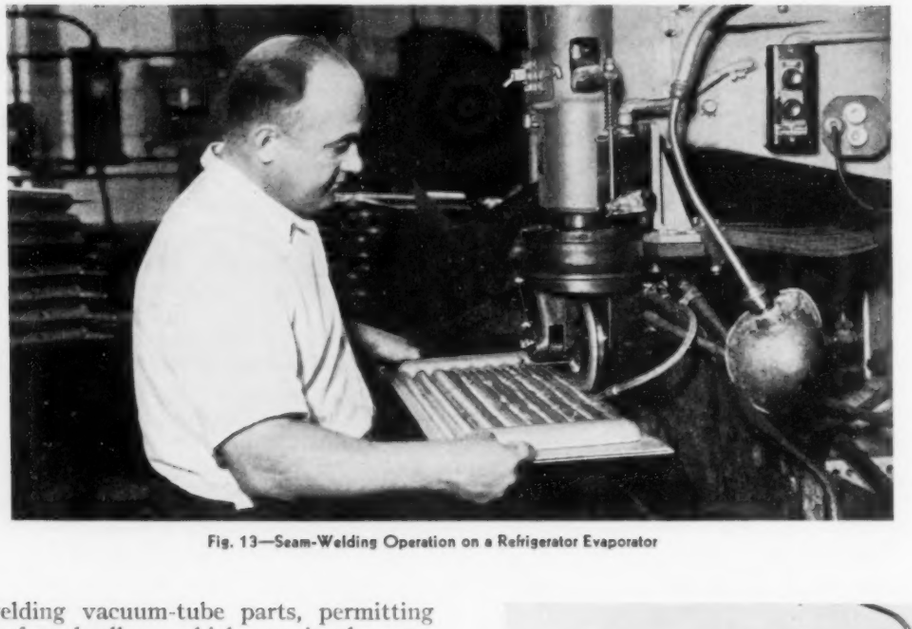


Fig. 13—Seam-Welding Operation on a Refrigerator Evaporator

(1) Spot-welding vacuum-tube parts, permitting the use of preferred alloys which previously were thought unsuitable for welding.

(2) Welding metal radio and industrial tubes by the use of spot- projection- and seam-welding methods (including the new metal thyratron and ignitron tubes themselves).

(3) Welding of high-strength aluminum alloys (for aircraft and other applications)—a production process which was made practical for the first time by the use of thyratron control.

(4) Fabrication of the new lightweight railway equipment.

(5) Making heat exchangers of stainless steel or aluminum for milk and other products.

(6) Welding of farm implements.

(7) Seam welding of metal beer kegs and paint containers.

(8) Control of heavy-duty welders to eliminate contactors and decrease maintenance cost.

It is interesting to note the contrast in the size of welding machines that are thyratron controlled. Some demand 2000 kva. or more; and others, which are used for delicate applications, such as are found in watch, optical, vacuum-tube and other industries, are rated only 3 to 5 kva.

Because of its dependability and superior welding ability, thyratron control has made a name for itself. Both in this country and abroad the satisfactory performance of early units, followed by additional installations (totaling about 500), demonstrates the reliability of this control for resistance welding.

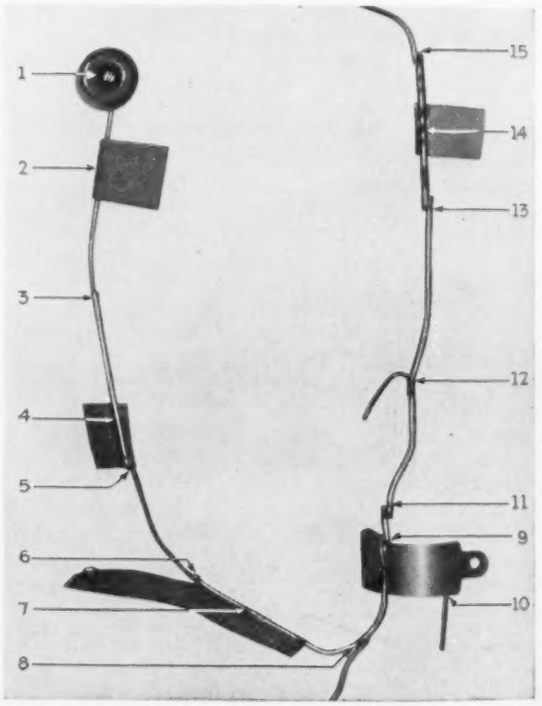


Fig. 14—Welds of Various Materials Made by Means of a Thyratron-Controlled Welder with a Timing of 1/2 Cycle

(1) Copper wire and brass
(2) Sheet nickel and soft nickel wire
(3) Soft and hard nickel wires
(4) Sheet nickel and hard nickel wire
(5) Hard nickel and molybdenum wires
(6) Molybdenum and Invar wires
(7) Perforated Nichrome and Invar wires
(8) Hard-nickel and Invar wires
(9) Invar wires and sheet Monel metal
(10) Sheet Monel metal and molybdenum wires
(11) Two Invar wires
(12) Soft-nickel and Invar wires
(13) Invar and Ascaloy wires
(14) Ascaloy wire and sheet nickel
(15) Ascaloy and hard-nickel wires

Manufacturing Special Truck Bodies

By M. L. ECKMAN†

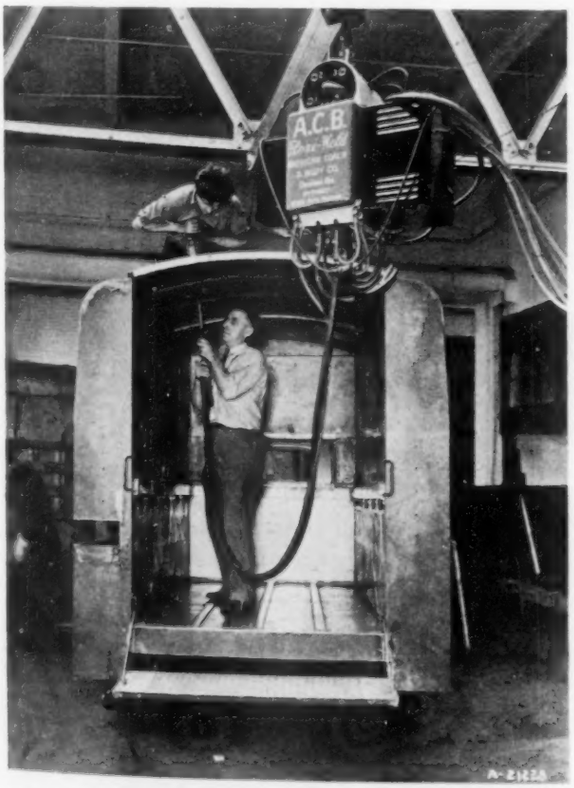
INSTALLATION and upkeep on telegraph and telephone lines, industrial and domestic gas and water service goes on so efficiently that it is only in event of an unusual catastrophe that the general public takes note of the process.

Next to the organization and personnel the modern equipment in use today is a major contribution to such service.

For instance within a very short time after a storm has disrupted your telegraph or telephone system one of our all steel trucks with enclosed cab, carrying a four to seven man crew will be speeding from the nearest base to take charge of the situation.

These trucks are really traveling work shops, marvels of ingenuity, the compartments provide for everything the repairman needs, trays and bins, provides a definite place for nuts, bolts, wire, cable, ropes, tools and etc., so that no time is lost in search, everything has a place protected from the weather and locked when traveling, yet readily accessible.

A power winch enables the crew to pull obstructions from the highway. A 15-ton derrick with jacks carried in the truck enables them to set poles, and a collapsible power reel speeds up cable pulling operations.



Making an Overhead with Portable Flexi-Welder. Man on Top Is Applying the Ground Lead. The Operator Makes the Weld by Manual Pressure

† Chief Engineer, Welding Division, The American Coach & Body Co.

Making a Difficult Weld in a Confined Space. Ground Lead Is Clamped to the Work and May Be 6 Feet Away

The Engineering of these Trucks is interesting. In the designing the following qualities are imperative:

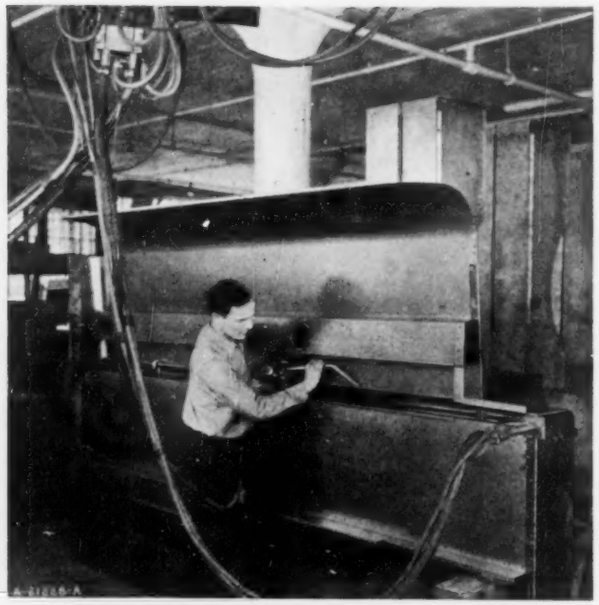
1. *Safety.*—All steel fabricated and welded construction gives, strength and sturdiness without excess weight, cutting down per mile costs.

2. *Utility.*—Every minute counts in utility service in consequence no effort has been spared to arrange all material and tools in convenient bins and trays, compactly built into the body yet readily accessible from the outside of the truck. Compact design gives more space for "pay load."

3. *Reliability and Economy.*—All metal, fabricated construction allows the even distribution of loads and stresses allowing for a "low hung" body, with neat stream lined appearance and full auto body finish. The maintenance on these trucks is negligible.

4. *Comfort.*—Workmen function well when their physical needs are taken care of. Workmen travel in well upholstered seats in heated and insulated cabs, with a periscope for inspection of overhead lines while traveling. The top may be put back when working. A thermostatic cask gives cool, clean drinking water. A folding table is provided for plans and calculations. Clothes lockers are built in. In manufacturing, the heavier eye beam and channel frames are "arc welded" to the "Inland Steel" four-way floor plates and some steel castings. About 20 men being employed in this department.

In the fabricating of the sides and tops of the trucks the engineers had a problem that taxed their ingenuity for a long time. These are made from commercial sheet steel, galvanized, galvaneal or stainless usually 18 or 20 gage with a smaller amount of 22 and 16 gage. The problem was to utilize the "Reliability and Economy" of Resistance Spot Welding, but the hitch was that they were too big and cumbersome to take to stationary spot welders and there were no portable welders on the market



Two Hands May Be Used in Applying Pressure in Difficult Positions

that would function with one electrode inside the body and the other outside—as much as 6 feet intervening and much of the welding "BLIND" that is the man on the inside being unable to tell exactly where the outside man was positioned.

After a great deal of painstaking work such a machine was developed and patented, and they have done remarkable work in the fabrication of these bodies.

It had been thought until recently that this was not a practical way to spot weld but at our plant they make hundreds of welds per day that are comparable to other welds made on stationary machines.

A series of tests were made at Case School of Applied Science to determine the comparative strength of the spot welds with the following results. All spot welds made on a production basis.

Material	A. C. B. Flexi-Welder Average (1-Spot)	Standard Motor Driven Spot Welder Average
20 gage to 20 gage	913 lb.	1006 lb.
20 " " 12 "	1073 "	993 "
20 " " 1/4 "	1137 "	1110 "
19 " " 19 "	1300 "	1320 "
19 " " 12 "	1483 "	1240 "
19 " " 1/4 "	1567 "	1570 "
17 " " 17 "	1570 "	1687 "
17 " " 12 "	1727 "	1613 "
17 " " 1/4 "	1973 "	1883 "

Practical proof is that approximately 3000 bodies fabricated with the new welder are in daily service from the Atlantic to the Pacific on jobs where they must stand up and give service.

The advantage of this welder, which has been called the Flexi-Welder, is that it is: *Portable, Flexible* and *Adaptable* beyond anything of its kind on the market. With a single light weight electrode they weld in "tight places" around radii, inside of compartments, even down in holes, at any angle.

Light metal is welded to heavy angle or tee iron and it doesn't seem to make much difference how heavy the scale is on the heavy frame.

The illustrations show the Welder at work on some of the truck bodies and it can be seen that the one electrode is clamped as a "ground" to the body. Welding 6 feet away can be done in this manner.

The Flexi-Welder will weld 16 gage and lighter to any gage sheet metal or heavy frame work and in operation is no more difficult than a stationary spot welder.

It consists of a specially built transformer, an electronic tube timer with high-speed contactor to operate from commercial 220-volt AC. current. Flexible cable water cooled enclosed in a rubber hose terminate in handles, that will accommodate a variety of offset of angular point holders.

The heat is regulated by a regulator giving 12 steps of heat regulation and the duration of current flow is regulated from $^1/_{15}$th to $^5/_{10}$ths of a second by graduated dial on the timer. Timing once set is automatic.

The simplicity of the outfit would seem to indicate it has a large field of usefulness in the fabrication of:

Metal furniture, metal doors and partitions, refrigerators and air conditioning equipment, steel houses, vending machine, auto-trailers, metal cabinets, stoves and ranges and similar products.

It brings spot welding into the realm of really portable tools.

Some of These Welds Would Be Difficult if Not Impossible to Make by Any Other Type of Welder

Specifications for Filler Metal (A 205 – 37 T)
2
Process

TENTATIVE SPECIFICATIONS
FOR
IRON AND STEEL FILLER METAL[1]
(ARC-WELDING ELECTRODES AND GAS-WELDING RODS)

Serial Designation: A 205 – 37 T

This is a **Tentative Standard** and under the Regulations of the Cooperating Societies is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the A.S.T.M., 260 S. Broad St., Philadelphia, Pa., or of the A.W.S., 33 W. Thirty-ninth St., New York, N. Y.

ISSUED, 1937.

These specifications were prepared jointly by the American Welding Society and the American Society for Testing Materials.

Scope

1. (*a*) These specifications cover arc-welding electrodes and gas-welding rods for the welding of carbon-steel shapes, plates, bars, pipe, forgings, castings and other steel products covered by the American Society for Testing Materials' specifications for material suitable for welding by the fusion process.

(*b*) The general purpose for which the filler metal is to be used shall be plainly stated in the purchase order. The statement of purpose shall include information as to the position of welding, such as flat or downhand, vertical, overhead, horizontal fillet, etc., also the welding process, such as gas, direct-current arc, alternating-current arc, or other process which the purchaser intends to use.

(*c*) Seven grades of filler metal are included, designated as Grades 2, 4, 10, 15, 20, 30, and 40, and classified in accordance with the tensile properties of the weld produced by the filler metal, as specified in Section 6 and in Table I (see Explanatory Note).

(*d*) Additional requirements (Paragraphs S1 to S8) of an optional nature are provided for use when the purchaser desires to test filler metal in the more complete manner indicated, such as when existing Code requirements must be satisfied, or the particular application justifies the expense of the additional testing. When it is desired that any of these additional requirements apply in any purchase, it shall be so stated in the order (see Explanatory Note).

[1] Under the standardization procedure of the two Societies these specifications are under the jurisdiction of the A.S.T.M. Committee A-1 on Steel, and of the A.W.S. Filler Metal Specifications Committee.

Process

2. The filler metal may be made by any process that will fulfill the requirements of these specifications.

Standard Sizes

3. Standard sizes of filler metal are as follows: $\frac{1}{16}$, $\frac{3}{32}$, $\frac{1}{8}$, $\frac{5}{32}$, $\frac{3}{16}$, $\frac{7}{32}$, $\frac{1}{4}$, $\frac{5}{16}$, and $\frac{3}{8}$ in. in diameter. In the case of coated or covered filler metal, the standard sizes refer to the diameter of the core wire. For manual welding, standard lengths for electrodes are 14 and 18 in.; for welding rods, 36 in.

Chemical Composition

4. The filler metal shall be capable of depositing metal conforming to the following requirements as to chemical composition:

Phosphorus, max., per cent	0.04
Sulfur, max., per cent	0.04

Chemical Analysis

5. (*a*) For arc-welding electrodes, the sample for analysis shall be prepared as follows: A specimen of standard base metal (see Table I) of sufficient size, shall be prepared, and a pad of five superimposed layers of arc metal deposited thereon. The fifth or top layer shall be ground or machined away and discarded. The fourth layer shall be carefully milled off and used for the analysis specified.

(*b*) For gas-welding rods, the sample for analysis may be prepared as described in Paragraph (*a*), except that three layers shall be considered sufficient and the top layer used for the analysis, or analysis may be made of the welding rod. In the latter case, ten rods shall be selected at random from the lot, and milled in such manner as to represent the entire cross-section.

All-Weld Metal Tension Tests

6. The deposited metal shall conform to the minimum tensile properties specified in Table I.

Test Specimens

7. (*a*) From each lot of 50,000 lb., or fraction thereof, of each size of filler metal submitted for inspection, a sufficient number of electrodes or welding rods shall be selected at random from various bundles or containers, and a deposited metal specimen prepared.

(*b*) The specimen shall be prepared in the position specified in the order. If more than one position is specified, a test specimen shall be prepared in each position specified. The welding process (gas, alternating-current arc, direct-current arc, etc.) specified in the order shall be used. The welding shall be performed by a qualified welding operator,[1] following the technique recommended by the manufacturer of the filler metal.

[1] For the requirements of a qualified welding operator, see "Tentative Rules for the Qualification of Welding Processes and Testing of Welding Operators," Am. Welding Soc., October, 1936.

(*c*) For $\frac{1}{16}$ and $\frac{3}{32}$-in. filler metal, the all-weld tension test is impracticable and the strength of these sizes shall either be judged by the strength of $\frac{1}{8}$-in. or larger filler metal or shall be determined by a joint specimen for tension test as covered in Paragraphs S3 and S4.

(*d*) For $\frac{1}{8}$-in. filler metal, a plate $\frac{3}{8}$ in. in thickness shall be prepared as illustrated in Fig. 1 and the subsize all-weld tension specimen prepared as shown.

TABLE I.—TENSILE REQUIREMENTS FOR DEPOSITED METAL.

Grade	Base Metal	Treatment of Welded Specimen[c]	All-Weld Tension Test	
			Tensile Strength, min., lb. per sq. in.	Elongation in 2 in., min., per cent
No. 2	A.S.T.M. A 70 Firebox quality steel plate,[a] tensile strength 55,000 lb. per sq. in., min.; or A.S.T.M. A 7 Steel for bridges,[b] tensile strength 60,000 lb. per sq. in., min., with carbon not over 0.25 per cent and manganese not over 1.00 per cent; or equivalent steels.	stress-relieved	80 000	20[d]
		non-stress-relieved	80 000	15[d]
No. 4	same as for Grade No. 2	stress-relieved	75 000	20[d]
		non-stress-relieved	75 000	15[d]
No. 10	same as for Grade No. 2	stress-relieved	60 000	25
		non-stress-relieved	60 000	20
No. 15	same as for Grade No. 2	stress-relieved	60 000	20
		non-stress-relieved	60 000	17
No. 20	same as for Grade No. 2	stress-relieved	52 000	10
		non-stress-relieved	55 000	7
No. 30	same as for Grade No. 2	stress-relieved	45 000	7
		non-stress-relieved	47 000	5
No. 40	same as for Grade No. 3	stress-relieved	45 000	5
		non-stress-relieved	47 000	3

[a] See Standard Specifications for Carbon-Steel Plates for Stationary Boilers and Other Pressure Vessels (A.S.T.M. Designation: A 70) of the American Society for Testing Materials, 1936 Book of A.S.T.M. Standards, Part I, p. 56.

[b] See Standard Specifications for Steel for Bridges (A.S.T.M. Designation: A 7) of the American Society for Testing Materials, 1936 Book of A.S.T.M. Standards, Part I, p. 1.

[c] Stress-relieving where called for in these specifications is for the purpose of developing the fundamental properties of the weld metal unaltered by locked-up stress. Values obtained from stress-relieved welded specimens are about 5 per cent lower in tensile strength and 10 to 20 per cent higher in ductility than those of non-stress-relieved specimens. The fact that a filler metal test requires stress-relief signifies only that it must develop the strength required regardless of stress-relief, and not that stress-relief must always be used in actual work. Stress-relieving shall be within the range of 1100 to 1200 F. for 1 hr. per 1 in. of thickness. Gas-welded specimens may be heat-treated at higher temperatures than the temperature specified above for stress-relief.

[d] It is immaterial how these high physical properties are obtained, that is, whether by carbon-steel filler metal with manganese and silicon contents or by the use of some other alloying elements, but the total amount of such other elements shall be less than 4 per cent.

(*e*) For $\frac{5}{32}$-in. and larger sizes of filler metal, a plate $\frac{3}{4}$ in. in thickness shall be prepared as illustrated in Fig. 2 and the tension specimen prepared as shown.

(*f*) Test plates shall be so supported that warping due to welding shall not throw the finished test plate out of line by an angle of over 5 deg. If plates are warped, they shall be straightened cold before being stress-relieved where required.

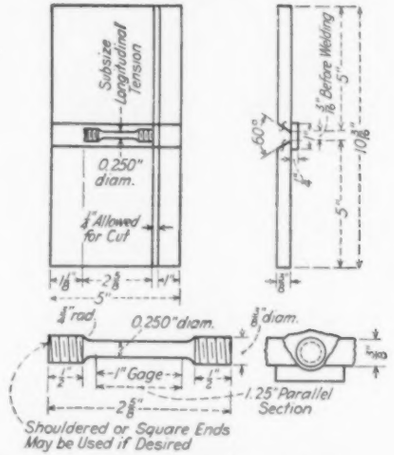
(*g*) The length of test plates may be increased as desired in order to provide material for additional tests when specified.

Retests

8. If the tension test specimen fails to conform to the requirements specified, three additional test plates shall be prepared as specified in Section 7, all of which shall conform to the requirements specified or the lot of filler metal shall be rejected.

Electrodes for Manual Welding

9. In the case of coated or covered electrodes for manual welding, about 1 in. of the electrode shall be bare or free from coating at the one end for making contact with the holder. The arc end shall be sufficiently



NOTE 1.—The above plate shall be used for $\frac{1}{8}$-in. filler metal.
NOTE 2.—Welds shall be deposited in either layers or beads.
NOTE 3.—Welds in vertical position shall be deposited upwards.
NOTE 4.—Electric welds shall cool to at least 100 F. between the deposition of each layer or bead.

FIG. 1.—Test Plate for $\frac{1}{8}$-in. Diameter Filler Metal and Method of Machining Specimen.

bare to permit easy striking of the arc, but the length of the bare portion of the arc end, measured from the end to the point where the full cross-section of the coating obtains, shall not exceed one nominal diameter.

Permissible Variations in Dimensions

10. (*a*) Cross-sectional dimensions shall not vary from that specified by more than ±3 per cent.

(*b*) Cut lengths shall not vary from that specified by more than $\pm\frac{1}{8}$ in.

Workmanship

11. (*a*) Uncoated filler metal and the core of coated or covered filler metal shall be of uniform quality free from injurious segregation, oxides, pipe, seams or other irregularities.

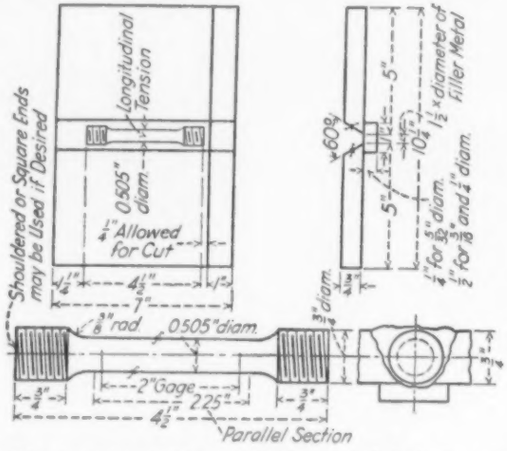
(*b*) On coated or covered filler metal, the coatings and coverings shall

(*c*) Purchase order number.

(*b*) On coated or covered filler metal, the coatings and coverings shall be such that they are not readily damaged by ordinary handling and shall be of commercially uniform thickness and shall present a workmanlike appearance. Coatings and coverings shall be free from injurious scabs, blisters, abnormal pockmarks, bruises or other surface defects.

Finish

12. The surface of gas-welding rods and bare electrodes shall be smooth and free from harmful scale, oil, or grease and shall be plain or copper finished, as specified.



NOTE 1.—The above plate shall be used for filler metal $\frac{5}{32}$ in. in diameter and larger.
NOTE 2.—Welds shall be deposited in either layers or beads.
NOTE 3.—Welds in vertical position shall be deposited upwards.
NOTE 4.—Electric welds shall cool to at least 100 F. between the deposition of each layer or bead.

FIG. 2.—Test Plate for Filler Metal $\frac{5}{32}$ in. in Diameter and Larger and Method of Machining Specimen.

Packing

13. Filler metal shall be suitably packed, wrapped, boxed or crated to insure against injury during shipment or storage, as follows:

(*a*) Bundles of 50 or 100-lb. net weight,
(*b*) Boxes or kegs of 50, 100, 200, or 300-lb. net weight, and
(*c*) Coils or reels of approximately 50, 100, 150, 200, or 300-lb. net weight.

Marking

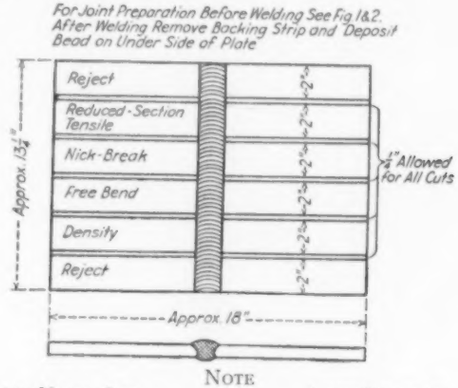
14. All bundles, boxes, kegs, coils or reels shall be legibly marked and bear the following information:

(*a*) Grade,
(*b*) Manufacturer's name and trade designation,

(*c*) Purchase order number,
(*d*) Size of filler metal, and
(*e*) Net weight.

Inspection

15. All standard tests and inspection shall be made at the place of manufacture prior to shipment, and at the manufacturer's expense, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.



NOTE

FILLER METAL, SIZE	PLATE THICKNESS
$\frac{1}{16}$ and $\frac{3}{32}$ in.	$\frac{1}{8}$ in.
$\frac{1}{8}$ in.	$\frac{3}{16}$ in.
$\frac{5}{32}$ in.	$\frac{1}{2}$ or $\frac{3}{4}$ in.

FIG. 3.—Test Plate for Additional Tests (see Paragraphs S4, S5, S6, S8).

Certification

16. When mutually agreed upon between the manufacturer and the purchaser, a certification that the material conforms to the requirements of these specifications shall be the basis of acceptance of the material.

ADDITIONAL REQUIREMENTS

S1. These additional requirements shall not be considered unless specified in the order, in which event the additional tests specified shall be made at the place of manufacture, at the purchaser's expense, and may be witnessed by his inspector before shipment of the material. The purchaser shall specify by number, the additional requirements desired.

Test Specimens for Additional Tests

S2. As specified in Section 7 (*g*), the standard test plates shown in Figs. 1 and 2 may be increased in length to furnish material for additional

tests S3, S4, S5, and S8. If it is desired to prepare a separate test plate for additional tests S3, S4, S5, and S8, this shall be done using the same base-plate material as specified in Table I and following the requirements specified in Section 7. This test plate shall conform to Fig. 3, and shall be cut up for test as shown.

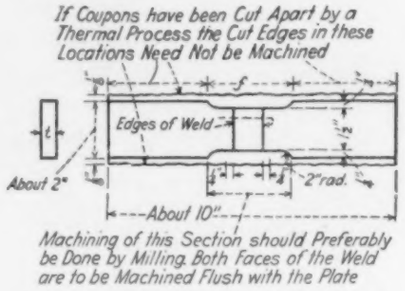

If Coupons have been Cut Apart by a Thermal Process the Cut Edges in these Locations Need Not be Machined
Edges of Weld
About 2"
2" rad.
About 10"
Machining of this Section should Preferably be Done by Milling. Both Faces of the Weld are to be Machined Flush with the Plate

FIG. 4.—Specimen for Tension Test of Welded Joint.

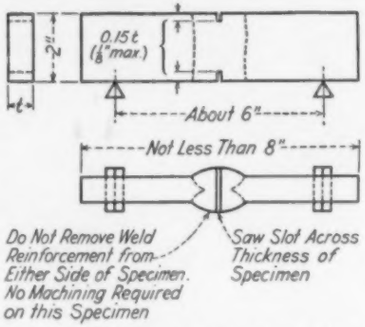

0.15t (⅛" max.)
2"
About 6"
Not Less Than 8"
Do Not Remove Weld Reinforcement from Either Side of Specimen. No Machining Required on this Specimen
Saw Slot Across Thickness of Specimen

FIG. 5.—Specimen for Nick-Break Test.

Tension Test of Welded Joint

S3. Test specimens of the welded joint, prepared as shown in Fig. 4 and stress-relieved unless otherwise specified, shall be tested in tension and shall conform to the following requirements:

GRADE	TENSILE STRENGTH, LB. PER SQ. IN.
No. 2	100 per cent of minimum base metal requirements
No. 4	100 per cent of minimum base metal requirements
No. 10	100 per cent of minimum base metal requirements
No. 15	100 per cent of minimum base metal requirements
No. 20	95 per cent of minimum base metal requirements
No. 30	85 per cent of minimum base metal requirements
No. 40	90 per cent of minimum base metal requirements

NOTE.—Before determining the tensile strength of the base metal, the specimen should receive the same heat treatment as is used in stress-relieving the welded test specimen.

Nick-Break Test

S4. (*a*) The nick-break test shall not be specified for Grades 30 or 40, nor for $\frac{1}{16}$ and $\frac{3}{32}$-in. filler metal of the other grades. The specimen for nick-break test of filler metal $\frac{1}{8}$ in. and larger shall be prepared as shown in Fig. 5. It shall be suitably supported as shown and broken by a sudden blow applied at the center of the weld. The blow should preferably be applied by a power hammer or falling weight, and shall be of sufficient intensity to cause a sharp, sudden fracture of the specimen through the nicked portion.

(*b*) The nick-break test for soundness of the weld shall show in the fractured surface of the specimen tested in accordance with Paragraph S4 (*a*) complete penetration through the entire thickness of the weld, absence of

oxide or slag inclusions and a degree of porosity not to exceed six gas pockets per square inch of the total area of the weld surface exposed in the fracture, the maximum dimensions of any such pocket not to be in excess of $\frac{1}{16}$ in.

Free-Bend Tests

S5. (*a*) The free-bend test shall not be specified for $\frac{1}{16}$ and $\frac{3}{32}$-in. filler metal. A prepared welded-joint specimen of filler metal $\frac{1}{8}$ in. and larger shall be capable of being bent at room temperature under free-bending conditions until the least elongation measured within or across approximately the entire weld on the outside fibers of the bend test specimen con-

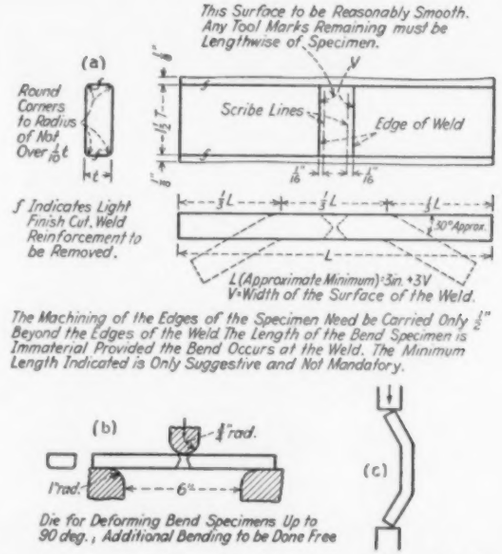

This Surface to be Reasonably Smooth. Any Tool Marks Remaining must be Lengthwise of Specimen.
(a)
Round Corners to Radius of Not Over 1/10 t
Scribe Lines
Edge of Weld
f Indicates Light Finish Cut. Weld Reinforcement to be Removed.
30° Approx.
L (Approximate Minimum) = 3n + 3V
V = Width of the Surface of the Weld.
The Machining of the Edges of the Specimen Need be Carried Only ½" Beyond the Edges of the Weld. The Length of the Bend Specimen is Immaterial Provided the Bend Occurs at the Weld. The Minimum Length Indicated is Only Suggestive and Not Mandatory.
(b)
1" rad.
6½"
(c)
Die for Deforming Bend Specimens Up to 90 deg., Additional Bending to be Done Free

FIG. 6.—Specimen for Free-Bend Test and Method of Testing.

forms to the values specified in Table II. When a crack is observed in the convex surface of the specimen between the edges, the specimen shall be considered to have failed. Cracks at the corners of the specimen shall not be considered as a failure. Superficial defects which do not increase in width as the bending progresses shall not be considered as failure.

(*b*) The preliminary bending of the free-bend test specimen may be performed by either of two methods, as illustrated in Fig. 6 (*a*) and (*b*). As in Fig. 6 (*a*), the bend in the specimen may be started by holding the specimen in a vise about one-third from the end, producing an initial bend at this point with hammer blows. Another bend about one-third from the other end is produced in the same manner. Or the bending of these

two points may be done in a bending die with pressure rather than hammer

Usability Test

fractured surface of the specimen tested in accordance with Paragraph S4 (*a*) complete penetration through the entire thickness of the weld, absence of

two points may be done in a bending die with pressure rather than hammer blows. As shown in Fig. 6 (*b*), the specimen shall be placed across two supports and bent by pressure up to 90 deg. After this preliminary bending by either method, the specimen shall be placed as a strut in a vise or compression testing machine, as illustrated in Fig. 6 (*c*), and pressure applied gradually, that is, without shock, at the ends until the gage length in the weld metal on the outside of the bend has elongated the amount specified in Table II, or until failure occurs.

TABLE II.—MINIMUM JOINT REQUIREMENTS, FREE-BEND TEST.

GRADE	TREATMENT OF WELDED SPECIMEN	OUTSIDE FIBER ELONGATION, PER CENT
No. 2	Non-stress-relieved or Stress-relieved, as Specified.	..
No. 4		..
No. 10		30
No. 15		25
No. 20		20
No. 30		10
No. 40		7

Coated or Covered Electrode Requirements

S6. (*a*) The coatings or coverings on electrodes shall be capable of withstanding ordinary handling, and bending to an angle of 30 deg. about a mandrel 2 in. in diameter, without flakes falling from the coating.

(*b*) The coatings on electrodes shall not be harmfully hygroscopic. They shall not be harmed by storage under normal storage conditions for periods up to nine months.

(*c*) The slag produced shall be readily removable by hand tools. Electrodes producing slag so hard as to necessitate the use of a power hammer for slag removal will not be acceptable.

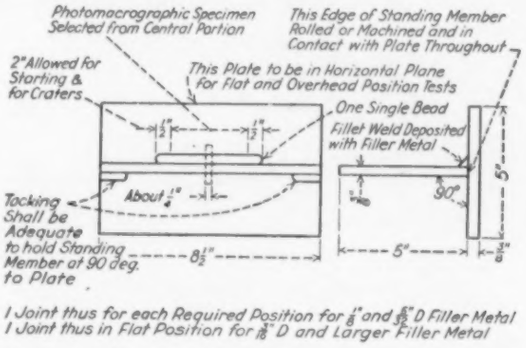
(*d*) The coatings and coverings on electrodes shall be concentric to the extent that for all sizes of electrodes the maximum core-plus-one-coating dimension shall not exceed the minimum core-plus-one-coating dimension by more than 3 per cent. The concentricity shall be measured as follows:

The coating or covering shall be removed from one side of the electrode (care being taken to insure that no metal is removed from the core) at about the center of its length. The core-plus-one-coating dimension (which is the diameter of the core plus the thickness of the coating on one side) shall be measured with a micrometer. The coating shall be removed from the opposite side of the electrode at a point distant from the place where the coating was previously removed, and a similar measurement made. Two more pairs of measurements of the core-plus-one-coating dimension shall be made on planes at angles of 60 deg. and 120 deg. from the plane of the former measurements. The pair of measurements which shows the greatest percentage of variation shall determine the acceptability of the electrode.

at this point with hammer blows. Another bend about one-third from the other end is produced in the same manner. Or the bending of these

Usability Test

S7. (*a*) Filler metal of Grades Nos. 2, 4, 10, 15, and 20 shall be capable of depositing, in all required positions, single bead fillets having a convexity ratio not greater than 30 per cent. If specified for Grades 30 and 40, the convexity ratio shall be not greater than 35 per cent. Fillet welded joints shall be made in each required position, from the same base plate material as used for all other tests, as shown by Fig. 7. Photomacrographic specimens shall then be cut, as shown in Fig. 7, from the center 6 in. of the fillet, which portion is assumed to represent the work of the filler metal;


Photomacrographic Specimen Selected from Central Portion
This Edge of Standing Member Rolled or Machined and in Contact with Plate Throughout
2" Allowed for Starting & for Craters
This Plate to be in Horizontal Plane for Flat and Overhead Position Tests
One Single Bead Fillet Weld Deposited with Filler Metal
1" 1"
About 1/4"
k
90°
5"
Tacking Shall be Adequate to hold Standing Member at 90 deg. to Plate
8 1/2"
5"
1 Joint thus for each Required Position for 1/8" and 5/32" D Filler Metal
1 Joint thus in Flat Position for 3/16" D and Larger Filler Metal

NOTE 1.—Fillets shall be best that welder can make after reasonable amount of practice.
NOTE 2.—Vertical welds shall be deposited upwards.
NOTE 3.—Fillets shall have the following maximum sizes:

Filler Metal Size	1/8 in.	5/32 in.	3/16 in.	1/4 in.	5/16 in.	3/8 in.
Fillet Size, max.	1/4 in.	5/16 in.	3/8 in.	1/2 in.	5/8 in.	3/4 in.

NOTE 4.—Use plates 3/4 in. in thickness for tests of 5/16 and 3/8-in. filler metal.

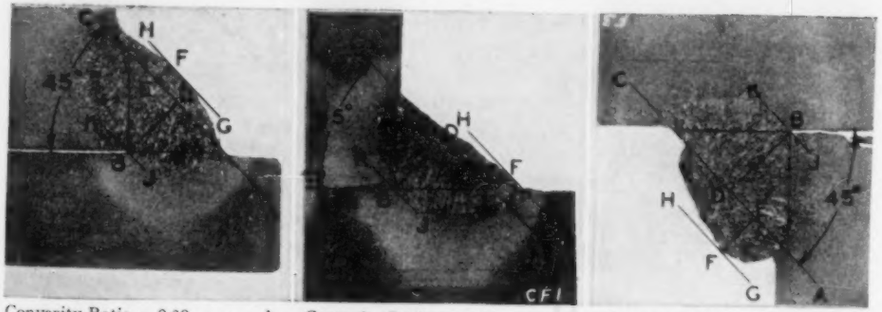
FIG. 7.—Specimen for Usability Test of Filler Metal.

a sufficient number of specimens being taken to thoroughly represent the specimen. The region where electrodes are changed shall be excepted from examination. Photomacrographs at a magnification of four diameters shall be made of the specimens, and examined for defects.

The convexity ratio of the fillets shall be determined as follows: On the photomacrograph a line at 45 deg. to the surface of the through plate shall be drawn internally tangent to the inmost point in the face of the fillet as shown by *A–C*, Fig. 8. A line parallel to *A–C* and tangent to the outermost point on the face of the fillet shall be drawn as shown by *G–H*; another line parallel to *A–C* and tangent to the base-and-weld-metal intersection nearest to *A–C* shall be drawn as shown by *J–K*; perpendiculars *E–F* and *D–B* shall be dropped to *A–C*, and the ratio of *E–F* to *D–B* shall be considered as the convexity ratio.

The photomacrographs shall also be examined for undercutting and overlapping.

(*b*) Electrodes which undercut, that is, reduce in any degree the original thickness of the base metal, in making any required type of weld



Convexity Ratio = 0.30.....A
Undercutting.....A
Overlapping.....A
Porosity.....A

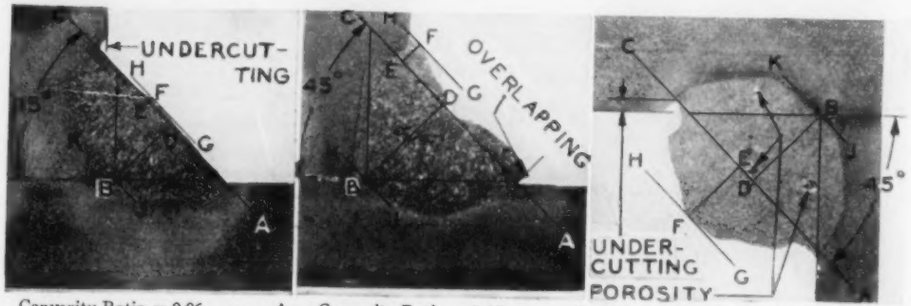
(*a*)

Convexity Ratio = 0.30.....A
Undercutting.....A
Overlapping.....A
Porosity.....A

(*b*)

Convexity Ratio = 0.56.....NA
Undercutting.....A
Overlapping.....A
Porosity.....A

(*c*)



Convexity Ratio = 0.06.....A
Undercutting.....NA
Overlapping.....A
Porosity.....A

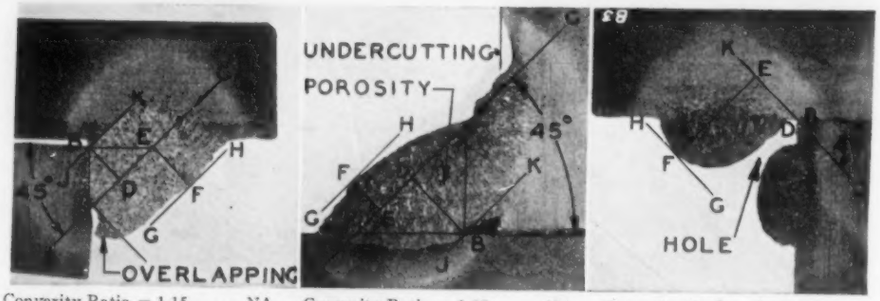
(*d*)

Convexity Ratio = 0.22.....A
Undercutting.....A
Overlapping.....NA
Porosity.....A

(*e*)

Convexity Ratio = 0.76.....NA
Undercutting.....NA
Overlapping.....A
Porosity.....NA

(*f*)



Convexity Ratio = 1.15.....NA
Undercutting.....A
Overlapping.....NA
Porosity.....A

(*g*)

Convexity Ratio = 0.55.....NA
Undercutting.....NA
Overlapping.....A
Porosity.....NA

(*h*)

Convexity Ratio = Inf.....NA
Undercutting.....A
Overlapping.....A
Porosity.....NA

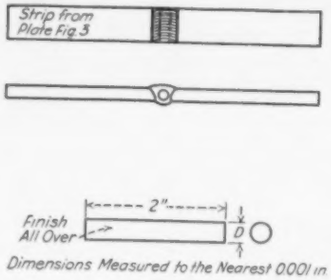
(*i*)

NOTE.—A. = Acceptable; NA = Unacceptable.

FIG. 8.—Acceptable and Unacceptable Fillet Welds.

in any required position shall not be accepted. For examples of undercutting, acceptable and non-acceptable, see Fig. 8.

(*c*) Electrodes making deposits which overlap or roll, that is, deposits which extend outside lines erected at the intersection of the base and weld metals, which lines are perpendicular to the base metal surface, in the case of bead and butt welds, and at 45 deg. to the base metal surface in the case of fillet welds, shall not be accepted. For examples of acceptable and non-acceptable overlapping, see Fig. 8.



NOTE

FILLER METAL SIZE	DIAMETER OF DENSITY SPECIMEN, D
$\frac{1}{16}$ and $\frac{3}{32}$ in.	$\frac{1}{8}$ in.
$\frac{1}{8}$ in.	$\frac{3}{8}$ in.
$\frac{5}{32}$ in. and larger	$\frac{1}{2}$ or $\frac{5}{8}$ in.

FIG. 9.—Specimen for Density Test of Filler Metal.

Density Determination

S8. The specimen for density determination shall be prepared as shown by Fig. 9. The density shall be determined by measurement and weight of the specimen, and not by the immersion method.

The results shall conform to the following minimum values:

GRADE	DENSITY (SPECIFIC GRAVITY)	GRADE	DENSITY (SPECIFIC GRAVITY)
No. 2	7.80	No. 20	7.75
No. 4	7.80	No. 30	....
No. 10	7.80	No. 40	....
No. 15	7.75		

EXPLANATORY NOTE

NOTE.—It has been most convenient to classify the several grades of filler metal in accordance with the tensile properties of the weld metal, that is, the results of so-called all-weld tension tests. Such values are probably of importance in nearly all applications of filler metal. For this reason, it has been made the basis of acceptance for general purposes. It has been clearly recognized that some fields of application, and many special cases, would require testing in a more complete manner. Also, it was appreciated that some applications would require specific requirements for coatings, and ability to deposit welds of restricted contour. To embody all of such requirements into the main body of the specifications would unduly penalize many producers and consumers alike. The most satisfactory method for handling such a situation was to include these various tests and requirements in the specifications as additional requirements of an optional nature, to be specified when and if required. There is no intent to convey the impression that they are of less importance than the all-weld tension test. The method of inclusion permits the selection of just those additional requirements that may be desired at any time.

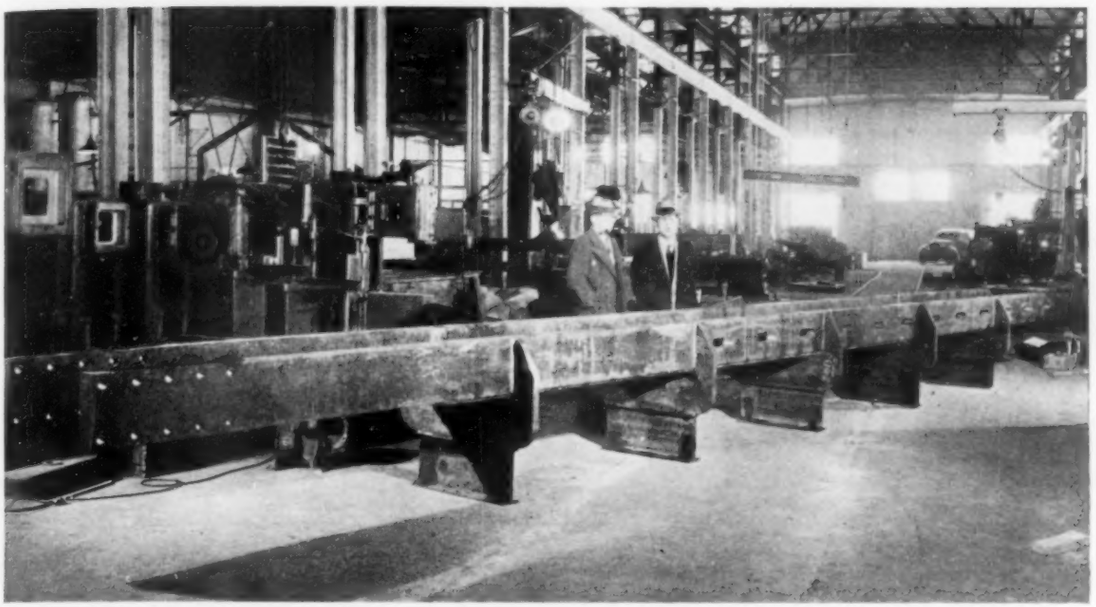


Fig. 1—Welded 200-Ton Chain Testing Press

Distortion Control in Fabricating a 200-Ton Chain Testing Press

By J. H. COOPER†

INASMUCH as distortion control in fabrication has always been of prominent interest to the AMERICAN WELDING SOCIETY, it may be of interest to readers of the JOURNAL as to the care required in fabricating the relatively simple structure shown in Fig. 1.

Figure 1 shows the main frame of a 200-ton chain testing press. In the final assembly a hydraulic cylinder is bolted between the two side rails using the drilled holes at one end of the frame.

In operation one end of the chain to be tested is restrained by means of a bar inserted through one of the matching pairs of $2^1/_2$ inch by 10-inch slots cut in the side rails. The other end of the chain is attached to the moving piston of the hydraulic unit and actuation of the piston loads the chain to the desired degree.

The press is so designed as to make very efficient use of the weld metal. The saddles perform the function of supporting, locating and stiffening the side rails. All of the testing load is taken by the side rails in compression.

The main frame as fabricated has a weight of 14,000 lb., is $38^1/_2$ feet long, 36 inches high and 41 inches wide.

The only features which required more than ordinary care in fabrication were the two side rails. These rails were $38^1/_2$ feet long, 12 inches wide and 3 inches thick. The most practical way of obtaining such sections was to gas-cut two pieces for each rail from 3-inch plate, out of 20 feet long standard sheets, and join them end to end to give a total length of $38^1/_2$ feet.

As the customer had specified these side rails to be straight within a tolerance of $^1/_{16}$ inch in $38^1/_2$ feet, great care in gas cutting and welding was exercised.

Knowing from experience that to cut such a section when it was free to move under the unequal expansion due to the heat of cutting one side only would result in a curved rail, we decided to cut both sides at once and leave the rail "tied-in" to the main plate as shown in Fig. 2 until cold.

Operating on this theory, two holes, 12 inches apart, were pierced with an oxyacetylene torch at one end of the sheet of 3-inch plate and a double cut made from these holes to a point approximately 3 inches from the other edge of the 20-foot plate.

After cooling the short uncut sections were cut out and a perfectly straight section was the result. The $2^1/_2$ inch by 10-inch slots were located and cut by means of a gas-cutting templet.

One end of each section was given a gas-cut "double-V" bevel for welding and the four sections aligned for joining to make the two long side rails. After tack welding great care was taken in alternating from end to end of each bevel and from one bevel to the other in welding

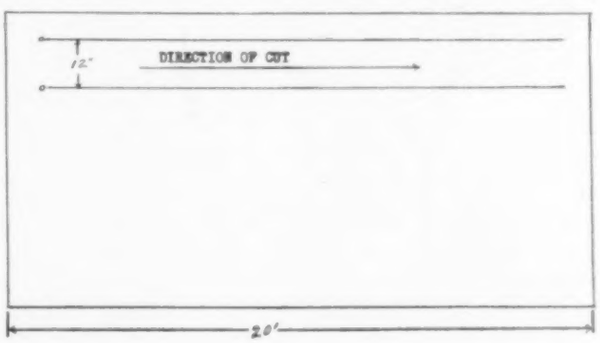


Fig. 2

† Welding Engineer, The Taylor-Winfield Corp.

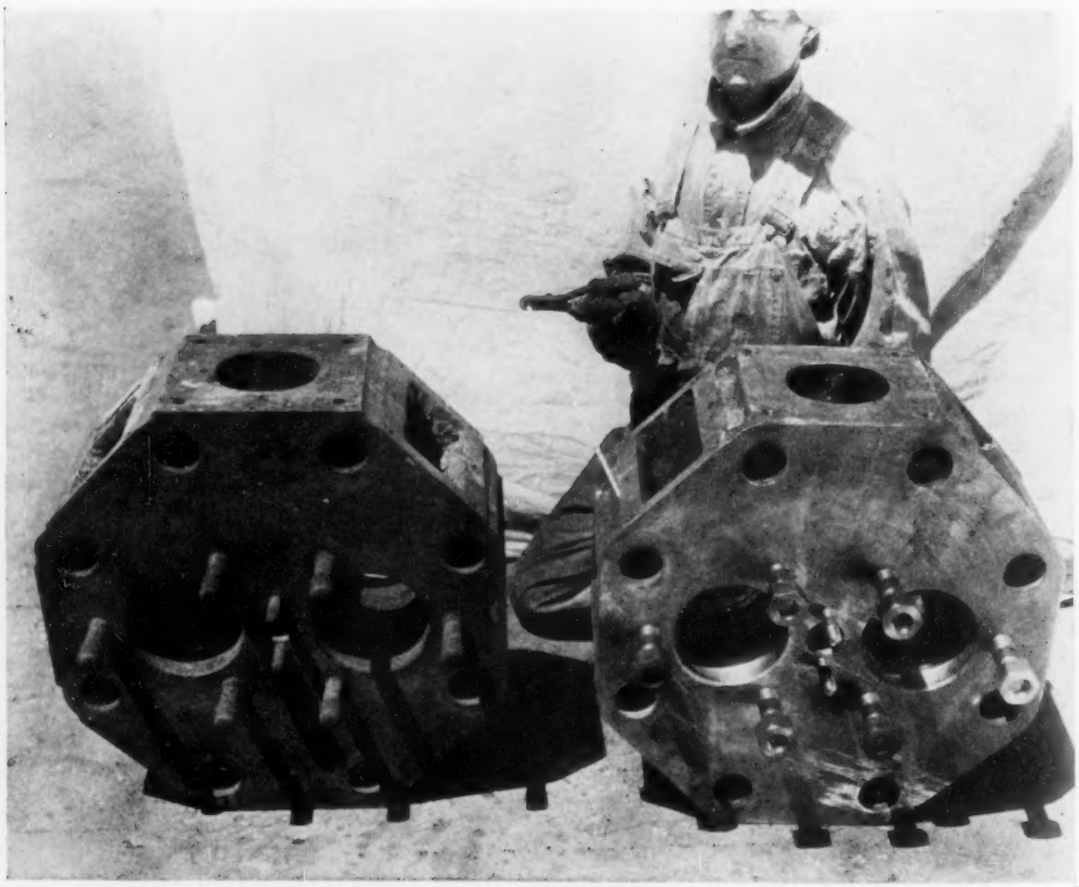
There is no intent to convey the impression that they are of less importance than the all-weld tension test. The method of inclusion permits the selection of just those additional requirements that may be desired at any time.

Note.—A = Acceptable; NA = Unacceptable.
Fig. 8.—Acceptable and Unacceptable Fillet Welds.

to maintain a straightness to meet such an exacting tolerance. As the press was not to be given a stress relief anneal, the locked-up stresses must be so proportioned as to balance as much as possible.

An electrode of the heavily coated mineral type was used with A.C. welding power supply. The excellent ductility of such deposited weld metal prevented any cracking under locked-up stresses of fairly high magnitude.

This press was designed by the Charles F. Elmes Engineering Works, of Chicago, and fabricated by the Taylor-Winfield Corporation, Detroit, Michigan.



Comparison of Welded Head with Original Casting (left)

Welded Diesel Engine Cylinder Head

By E. L. MATHY†

THE Southern Pacific Golden Gate Ferries, Ltd. operating the largest fleet of ferry boats on San Francisco Bay, are perhaps the first ones to have applied the economies and versatility of the arc-welding process in the fabrication of Diesel engine cylinder heads.

The cracking of the cast-iron heads on one type of Diesel engine, of which the company has twenty-four in service, became a very grave problem. After five years' operation there had been fully 100% replacement of these heads. Efforts were made to repair cracked heads by welding both by the company mechanics and in contract welding shops, but a very small percentage of these repairs were successful.

Finally, Maintenance Superintendent, A. C. Piercy, conceived the idea of fabricating the heads completely of steel by the arc-welding process. All parts of the heads are made of steel plates or tubes except the intake and exhaust passages which are steel castings. The illustrations give a clear picture of the construction features of heads. The bottom plate is 1 inch thick and top plate $^3/_4$ inch. In designing the heads it was necessary,

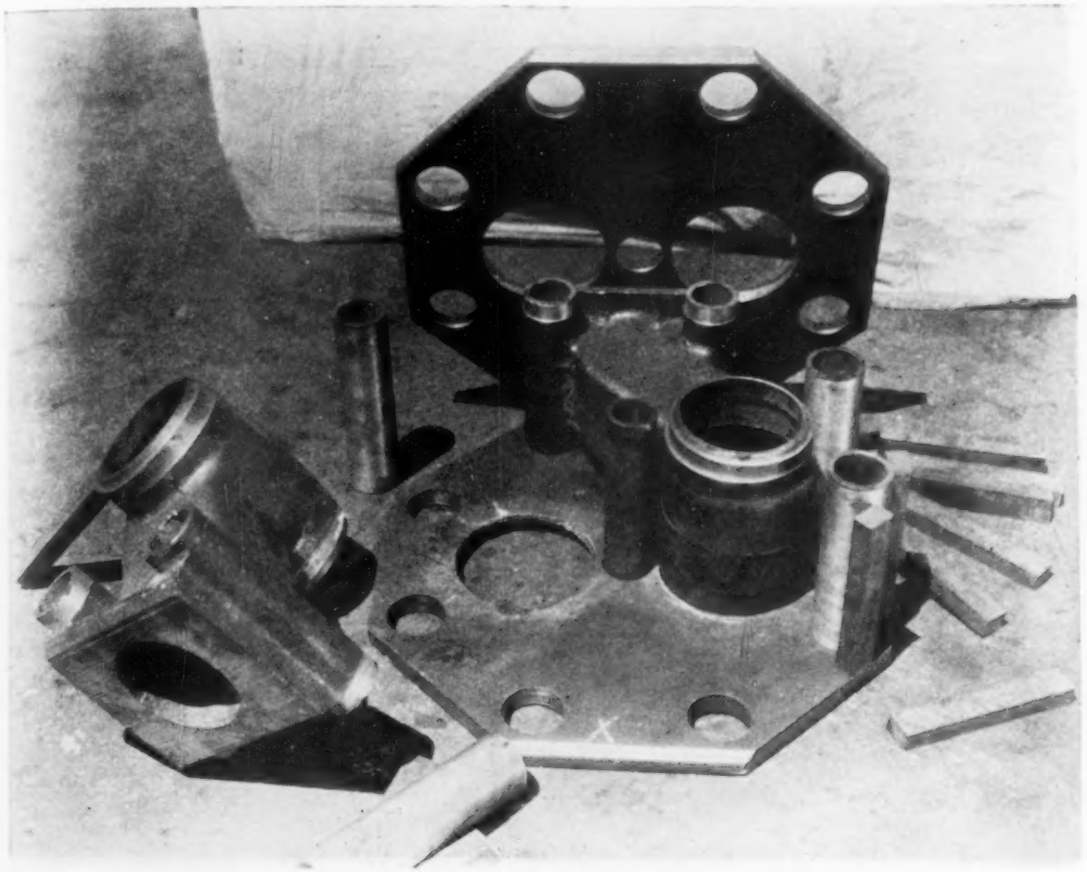
† First Vice-President, Victor Equipment Company

of course, to make the dimensions the same as the original heads so as to fit the existing manifolds, valves, etc.

The welded heads are lighter than the cast-iron ones, the water spaces are larger and smoother and they will not crack. All welds are on the outside away from the action of the sea water in the water spaces. The interior of these water spaces is protected from the action of the cooling water by a protective coating which has proved very satisfactory.

Four heads have now been completed and others are in the course of fabrication. The first one installed some five months ago has been entirely satisfactory. The operators now believe that these fabricated heads are the solution of their head problems.

All work was done in the shops of the Southern Pacific Golden Gate Ferries, Ltd. under the direct supervision of Mr. F. D. Meagher, the company's Shop Foreman.



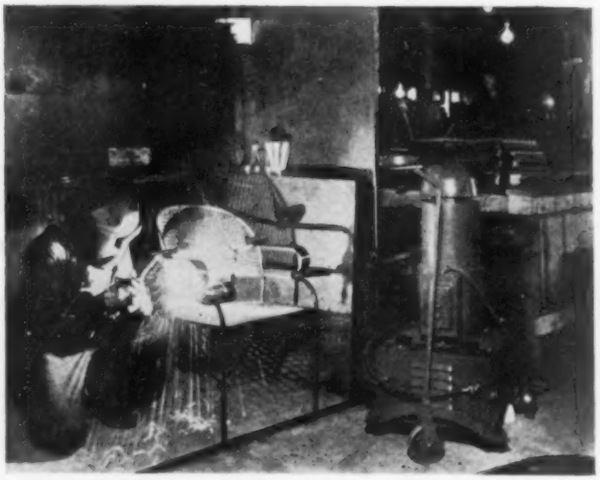
Parts Before Assembly Including Cast Valve Throat

Making Furniture

By A. F. DAVIS†

THE modern cabinet maker uses a new kind of "glue" and makes all kinds of furniture of metal instead of wood. Building chairs, stands, swings, benches, beds, etc., out of steel, he fuses the parts together with "glue" in the form of molten metal applied by the electric arc process of welding. So much simpler is this method of cabinet making, that it greatly reduces furniture manufacturing costs.

The furniture manufacturer in whose plant this photo was taken (Howell Company, St. Charles, Ill.) reports savings up to $30 a day on a single job by change-over to arc welding.



†Secretary, The James F. Lincoln Arc Welding Foundation.

Qualifying Welding Operators for Important Work

EDITOR'S NOTE: *The question is often raised as to how one goes about qualifying an operator for important work: The American Welding Society has issued "Tentative Rules for the Qualification of Welding Processes and Testing of Welding Operators." The first part includes comprehensive tests for qualifying the particular process and procedure. Having established that a given process is satisfactory it is then necessary in the qualification of welding operators to determine only their ability to produce sound welds by that process. The minimum values to be attained in tests and frequency of requalification are in turn specified by the particular code governing the specific application. Additional comments are invited.*

Structural Work: Gilbert D. Fish, Consulting Engineer

"Replying to your inquiry regarding suitable procedure for employers to follow in qualifying welders for structural work, I feel that the preparation of test specimens as described in the A. W. S. Building Code is so simple that no detailed instructions are needed. The specimens are completely described in the appendix of the Code and any mechanical testing laboratory is able to break them and report on the results."

Boilers, Piping, Insurance: E. R. Fish, Chief Engineer, Boiler Division, The Hartford Steam Boiler Insp. & Ins. Co.

"We also have innumerable requests from both individuals and firms asking for information about the qualifying and certification of welders. Many individuals are anxious to get a certificate from us stating they have passed certain tests.

"We have never made a practice of issuing any sort of certificate to individual welders. Our practice has been confined to the investigation of welding procedures set up by shops, leaving it to the shop management to qualify their own welding operators.

"The foregoing is what, in substance, we tell to the various inquirers and, furthermore we almost invariably refer them to the A. W. S. Rules for Qualifying of Shop Procedure and the Testing of Welding Operators. It is the principle of these Rules that we follow very closely.

"Occasionally some shop or industry that employs welders asks us to supervise the qualifying of their men and we have done this in a few cases although we insist upon some definite procedure being worked out by the employer beforehand so that the qualifying of the welders is not on a hit or miss basis.

"The A. W. S. Rules do not contain any numerical quantities and for these we are guided by the requirements of the A. S. M. E. Code, the A. P. I.-A. S. M. E. Code or the A. S. A. Code for Pressure Piping.

"We have always been antagonistic to the certification of individual welders since we thoroughly believe in the principle that a certain procedure must first be set up that will assure getting welds of proper physical qualities. Thereafter, it is the welder's duty to follow the prescribed procedure and to demonstrate his ability to get sound welds.

"So much potential danger lies in permitting welding to be done by unsupervised welders, claiming to be able to do any kind of welding under any conditions, that we believe the practice of issuing certificates to welders should not be established.

"Not only must the actual welding be properly done but the design of welded parts and the sequence of the application of the welding is very often of great importance. We have had many experiences where ignorance, on the part of the welder, of the effects of expansion and contraction, etc., has resulted in expensive failures.

"I think that the A. W. S. Rules should form the basis for the guidance of those doing welding either as employer or employee."

Preparation and Training Essential to Hold Costs to Minimum: *Recent survey and field contacts emphasized the following points to American Welding Society Managing Director who states:*

"The qualification of a welder is not mysterious. First of all there is a period of training for which the operators and their employer are responsible. The length of training will of course be dependent on previous experience and the nature of the work. Some employers have estimated it costs anywhere from $300 to $1000 before an operator becomes qualified to meet the tests for their work.

"Employers because of the special character of their work will not issue a certificate of competency as that competency is dependent in no small degree on the process and procedure used when the qualification tests were made. These may be quite different in various shops or plants. They do, however, in many cases issue an identification die (numbered or lettered) to each operator who becomes qualified in their procedure for stamping their welds.

"In code work and in contract work where the welding must pass inspection the procedure of the plant or shop must first be qualified and then those operators necessary to carry out work. The cost of qualifying these procedures is necessarily dependent upon the thoroughness of the preparation to meet the tests. Lack of preparation of plant or operator requires more time and expense of inspector and sometimes retests.

"Both the process and the operator have to be qualified to perform welding on important work.

"Thus a qualified welder-operator might pass inspection test at one plant where the process is also passed and yet he would go to another plant but would have to have his qualifications for this new process and work verified. A certificate or record from one plant can only be accepted at another plant as a record of past activities. Thus, inspection service, testing laboratories, insurance companies, rating bureaus or employees issue no interchangeable certificates or guarantees that waive necessity for qualifying under new conditions and periodically under the same conditions.

"It is like golf. You may shoot and qualify for a match on one links but that is no proof you could on another links even in the same city. It is all a matter of preparation for tests and *training* on the particular work in the plant under inspection.

"To date there is no general certification of welders

which would enable them to go to work anywhere or which would certify them as 'qualified' under any conditions."

Bridges, Structural and Code Requirements: R. B. Lincoln, National Weld Testing Bureau, Pittsburgh Testing Laboratory

"We are very glad of the opportunity to tell you about the work done by our Bureau. The usual procedure in qualifying welders is for a representative of the Bureau to witness the welding of the test specimens in accordance with the code under which the qualification test is to be made. For structural work, The AMERICAN WELDING SOCIETY'S Code for Fusion Welding and Gas Cutting in Building Construction usually applies. The new specifications for the Design, Alteration and Repair of Bridges is replacing it in its particular field. The American Standard Association's Tentative Code for Pressure piping usually applies in pipe welding and the American Society of Mechanical Engineers Code for Unfired Pressure Vessels of course applies to pressure vessel work. Occasionally, we are called upon to make tests in accordance with a customer's specifications that differ from the above codes. There is no objection to doing this, but when our advice is asked, we recommend following these standard codes, so as to avoid the unnecessary repetition of tests.

"After the specimens are welded, we mark them with our stamp for identification. Where machining is required, it may be done by the client or in our laboratory as he prefers. The specimens are tested in our laboratory, or we witness the testing on any apparatus known to be accurate. If the specimens comply with the requirements of the code, we issue a certificate to the employer, carrying a photograph of the operator tested. Attached to the certificate is a complete record of the test, as well as a specification for the welding process describing the welding technique used during the test.

"The client may write the specification for the welding process, but frequently we write it from data secured when we witness the welding of the specimens. We then submit it to the client for his approval and signature.

"Our certificates have been generally accepted by purchasers, insurance companies and governmental bodies. This is quite an advantage to the client because it frequently happens that he will qualify for a particular job and later receive another order which he can fill without additional qualification tests.

"When the above certificates are not required, we frequently receive welded plates or finished test specimens from the client. Of course, where we have not witnessed the welding of the specimens, we are not in a position to certify as to the identity of the operator or the welding process used."

Merchant Vessels: Chief, Technical Division, Department of Commerce, Bureau of Marine Inspection and Navigation

"In so far as this Bureau is concerned the tests of welding operators to determine their skill and ability to make sound welds are incorporated in Bureau Circular Letter No. 129.

"Operators who fail to pass the primary tests are permitted to furnish retest specimens, which, if passed successfully, are accepted and the welding operator certified.

"The qualification covers a period of one year from the date of the tests, at which time retests are made in accordance with the requirements for retesting welding operators, contained in the above-mentioned circular."

There follows Extracts from Circular Letter No. 129.

Primary Tests of Welding Operators

Individual welding operators who have not as yet passed their qualification tests are required to furnish specimens of their work for tests by this Bureau. The specimens are required to be prepared in the presence of a duly authorized inspector, stamped with his initials and the initials of the operator preparing the specimens and forwarded to the National Bureau of Standards, Division 6, Section 5, Washington, D. C.

Where specimens are machined, the side on which the top of the weld is located shall be marked "F" to indicate the face of the weld, said marking to be placed only on one end.

Inspectors who witness the preparation of the test specimens are required to report the preparation of these specimens on official Form 964 (formerly 76), copies of which will be furnished to Local Inspectors, and forward same to the Bureau as soon as possible.

The mill test report of the plate used in the preparation of the specimens, or preferably the inspector's report, if tested marine steel is used, shall be forwarded to the Bureau with Form 964 (formerly 76). If inspector's report or mill test report is not available, a specimen of the solid plate (without welds) from which the specimens are prepared shall be submitted in order to determine the physical properties of the base metal.

The minimum thickness of the material used shall be $^5/_8$ inch, and the maximum, one inch. The specimens may be submitted either in the stress-relieved or in the unstress-relieved condition.

Operators' Certificates

Certificates are now being issued to welding operators who have successfully passed the prescribed tests. Three copies will be prepared for each welding operator, one copy to be retained in the Bureau's files, one copy for the Local Inspectors in the district where the operator is employed, and one copy for the operator, to be delivered to the employer and kept in his files as long as the operator is employed by him; it shall be available to inspectors at all times. It will be necessary that each operator furnish three small photographs of himself to be attached to the certificate. It is the duty of the inspector to see that these photographs are pasted in the proper place on the last sheet of the certificate; he shall also witness the impression of the thumb-print of the operator's right hand in the place provided therefore, and shall obtain his signature. These acts shall in all cases be witnessed by the inspector, after which the copy marked "Bureau copy" shall be returned to the Bureau.

When an employee leaves his position, the manufacturer is requested to fill in the blank service record on the last sheet, certifying the date upon which the employee left his employ, and the reason therefor.

Welding operators who have qualified in the electric metallic arc process will be classified as *A*, *B* and *C* welding operators as follows:

Operators who have qualified in the overhead position, by hand or machine, will be classed as *A* welding operators, and given an identifying number, the entire symbol reading "*A*-1," "*A*-2," etc. Such welding operators will be permitted to do welding in any position by the process and method for which they have qualified.

Welding operators who have failed to qualify in the overhead position, but have passed their tests in the vertical position, will be permitted to do welding in the vertical, horizontal or flat positions, and will be designated as *B* welding operators, the symbol being "*B*-1," "*B*-2," etc.

Welding operators who have failed to qualify in the overhead and vertical positions, but who have successfully passed their tests in the horizontal or flat positions, will be classed as *C* welding operators, the symbol being "*C*-1," "*C*-2," etc.

Welding operators who have qualified by the gas process will be classified as *D*, *E* and *F* operators as follows:

Operators who have qualified in the overhead position, by hand or machine, will be classed as *D* welding operators, and given an identifying number, the entire symbol reading "*D*-1," "*D*-2," etc. Such welding operators will be permitted to do welding in any position by the process and method for which they have qualified.

Welding operators who have failed to qualify in the overhead position, but have passed their tests in the vertical position, will be permitted to do welding in the vertical, horizontal or flat positions, and will be designated as *E* welding operators, the symbol being "*E*-1," "*E*-2," etc.

Welding operators who have failed to qualify in the overhead and vertical positions, but who have successfully passed their tests in the horizontal or flat positions, will be classed as *F* welding operators, the symbol being "*F*-1," "*F*-2," etc.

Inspectors

Inspectors shall be assigned by the Local Board of the district where the boiler manufacturer's plant is located, to remain on duty in the plant and supervise the construction of boilers by any process of fusion welding. When boilers are being constructed for use on vessels subject to the jurisdiction of this Bureau, it shall be the duty of the inspector to satisfy himself that the work is being done in strict accordance with all of the requirements of the rules; but, where the plant is operated on a day and night basis, it will not be necessary to have an inspector stationed at the plant day and night. The inspector on the day shift shall check up on the welding operators employed on other shifts, examine the fit-up of the work, etc. This can be arranged so that the welding may be carried on continuously.

CURRENT WELDING LITERATURE

Aluminum. Oxyacetylene Welding of Aluminum, F. Zimmermann. Aluminum & Non-Ferrous Rev. (June 1937), vol. 2, no. 8, pp. 295–297.

Boiler Manufacture. Metallic Arc Welding for Steam Generating Plant, H. Harris. Fuel Economist (Apr. 1937), vol. 12, no. 139, pp. 245–249.

Cars, Freight. All-Welded Hopper Cars, K. T. Nystrom. Welding Engr. (June 1937), vol. 22, no. 6, pp. 26–30.

Cars, Passenger. Welded Steel in Railroad Service, E. Chapman. Iron Age (June 24, 1937), vol. 139, no. 25, pp. 50–51.

Electric Welding, Arc. Electric Arc Welding, P. J. Risdon. Elec. Welding (June 1937), vol. 6, no. 35, pp. 134–144.

Electric Welding, Arc. Influence of Electric Arc on Properties of Weld Metal, E. F. Newell. Elec. Welding (Apr. 1937), vol. 6, no. 34, pp. 102–104, (June) no. 35, pp. 161–164.

Electric Welding, Arc. Weldability of Steel. Boiler Maker & Plate Fabricator (June 1937), vol. 37, no. 6, pp. 149–151.

Electric Welding, Resistance. Resistance Welding Circuit, C. L. Pfeiffer. Elec. Eng. (July 1937), vol. 56, no. 7, pp. 864–868.

Electric Welding, Resistance. Sealed-Off Ignitrons for Welding Control, D. Packard and J. H. Hutchings. Elec. Eng. (July 1937), vol. 56, no. 7, pp. 875–877.

Electric Welding, Resistance. Theory of Resistance-Welding Circuit, L. H. Frost. Welding Engr. (June 1937), vol. 22, no. 6, pp. 32–33.

Electric Welding, Resistance. Spot and Seam Welding (Resistance) of Aluminum Alloy Sheet, D. I. Bohn. Metal Progress (July 1937), vol. 32, no. 1, pp. 53–56.

Gasoline Tanks. Welded Gasoline Storage Tanks, C. H. S. Tupholme. Petroleum Times (June 12, 1937), vol. 37, no. 96, p. 805.

Iron and Steel Metallurgy. Effect of Heat on Iron and Steel, E. D. Soderstrom. Welding Engr. (June 1937), vol. 22, no. 6, pp. 18–21.

Oil Tankers. Recent Practice in Welding Large Oil Tankers, J. W. Hudson and T. M. Jackson. Pac. Mar. Rev. (July 1937), vol. 34, no. 7, pp. 34–36.

Oil Tankers. Welding Gains Favor in Tanker Construction, K. A. Ringdahl. World Petroleum (Apr. 1937), vol. 8, no. 5, pp. 77–79.

Oil Wells. Story of First Welded Casing in Mid Continent Told in Pictures. World Petroleum (June 1937), vol. 8, no. 6, pp. 72–73. Illustrations and brief text describing welding of 5968 ft. string of casing as it was being run in hole of Carter Oil Co. No. 4 W. T. Miller well in Crescent field, Oklahoma.

Oxyacetylene Cutting. Reducing Waste. Oxy-Acetylene Tips (July 1937), vol. 16, no. 7, p. 156.

Pipe Lines. Oxyacetylene Welded Pipe Joints—Scope, Utility and Economics, T. W. Greene. Metal Progress (July 1937), vol. 32, no. 1, pp. 36–41.

Railroad Structures. Good Practice in Structural Welding. Ry. Eng. & Maintenance (July 1937), vol. 33, no. 7, pp. 474–476 and 480.

Rails. "Sledding," Latest in Long Rail Transportation. Ry. Eng. & Maintenance (July 1937), vol. 33, no. 7, pp. 481–483.

Steam Turbines. Turbine Runner Repaired. Oxy-Acetylene Tips (July 1937), vol. 16, no. 7, p. 157. Cast bronze patches to replace worn fins welded into place.

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Welding Joins the NAVY

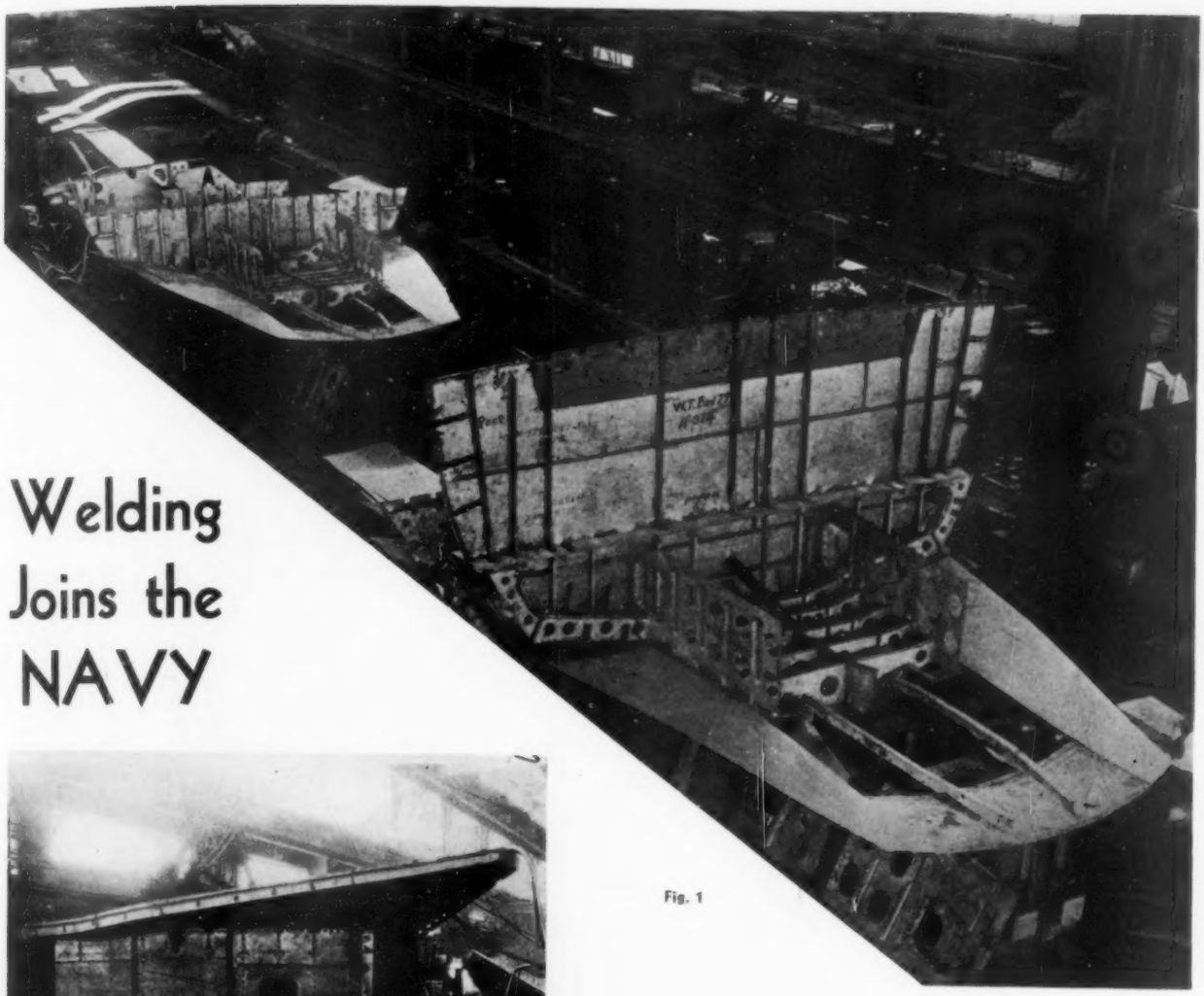
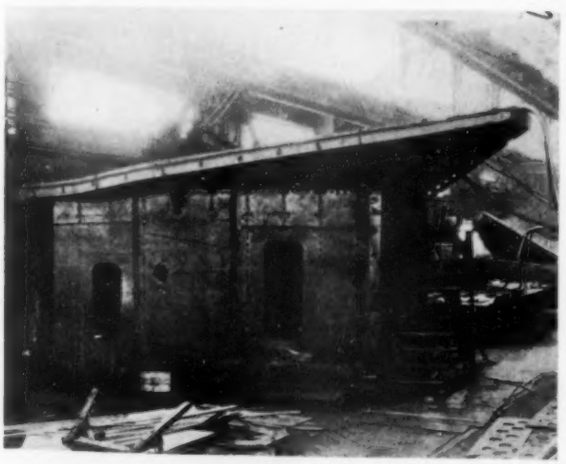


Fig. 1



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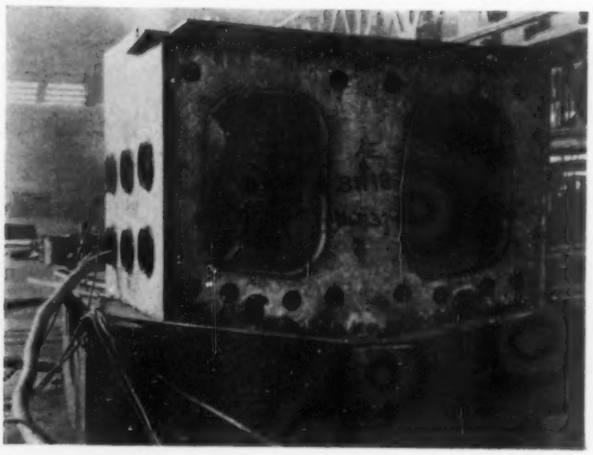


Official U. S. Navy Photographs

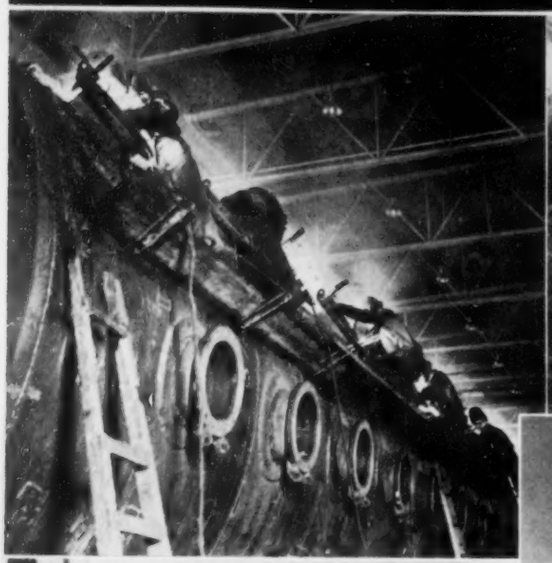
Fig. 1—Transom Sections

Fig. 2—Forward Section of Deckhouse

Fig. 3—Shop Assembly of Bow Framing

Fig. 4—Rudder Bearing Weldment

WELDING'S ROLE IN TH



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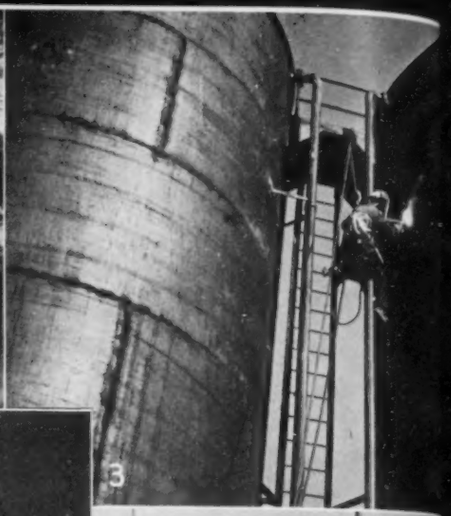

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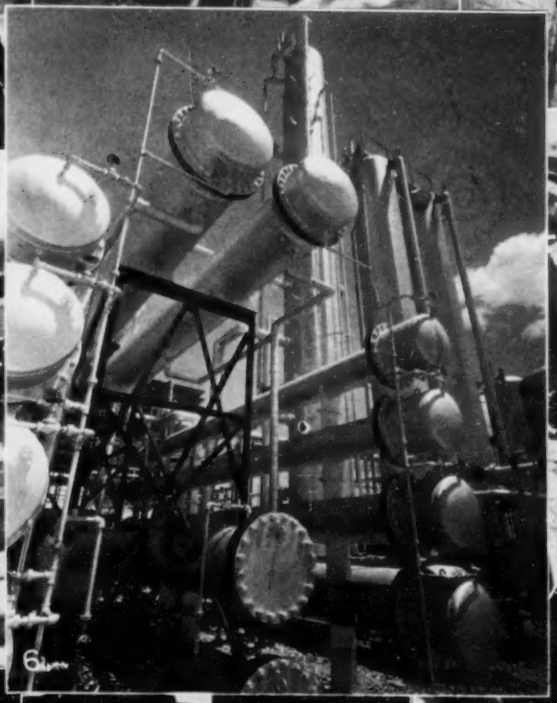

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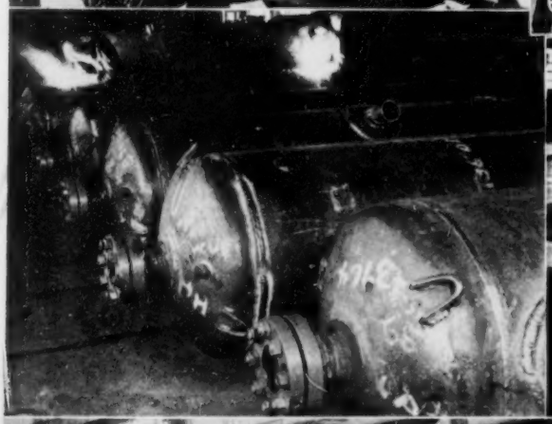

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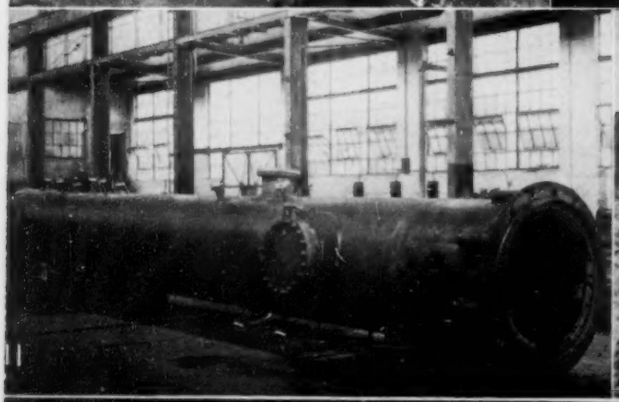

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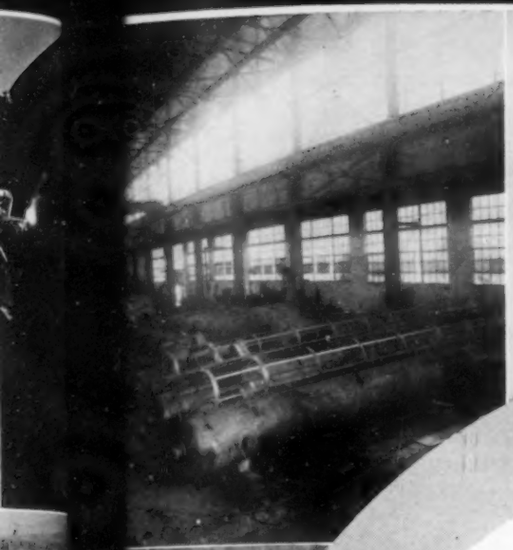
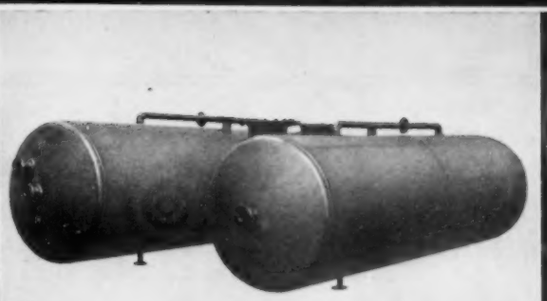
3. Welding Intake Pipe on a Shell Co.
4. 96 Ft. Welded Bubble Tower. Courtesy American Murex Corp.
5. Arc Welding Orange Peel Ends on Headers. Lincoln Electric Co.
6. Welded Natural Gasoline Plant.
7. Line-Up Weld on Shell Co. Pipe Line
8. 500 Lb. Separators on Welding Line Black, Sivalls & Bryson
9. Fabrication of Gasoline Storage Tank

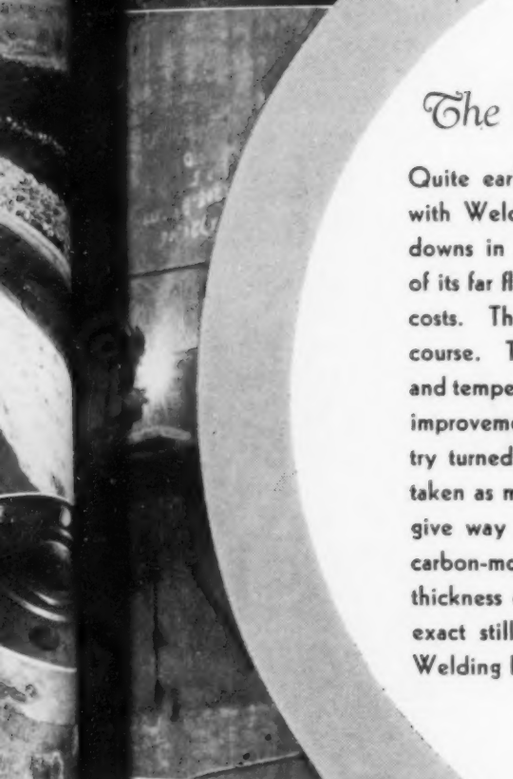
TH ETROLEUM INDUSTRY

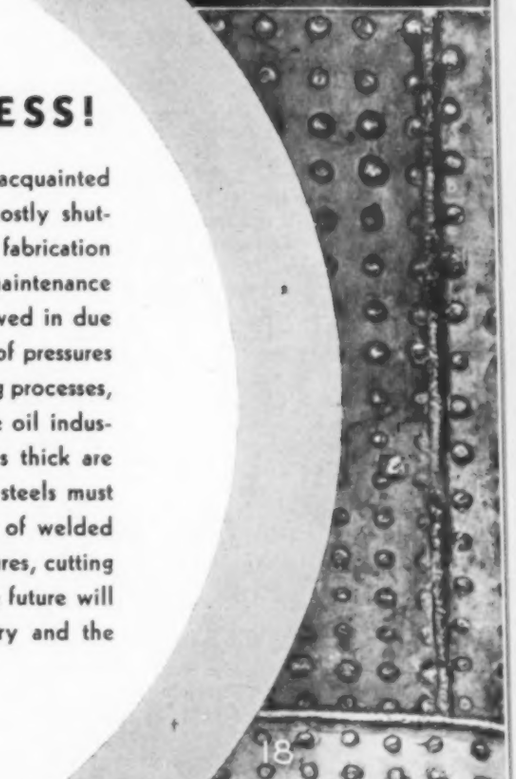


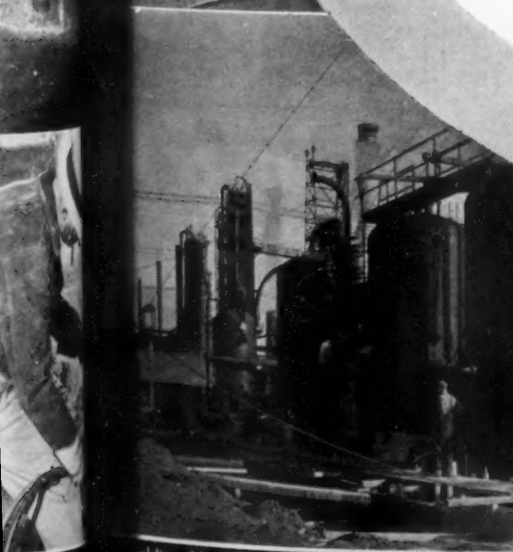


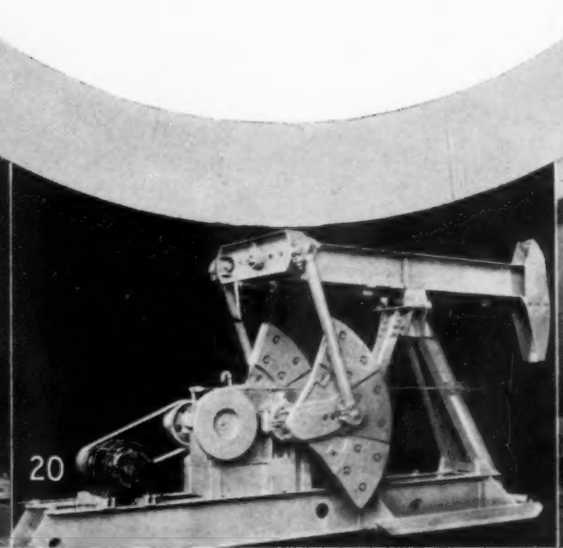
The FRONTIERS of PROGRESS!

Quite early in its history the Petroleum Industry became acquainted with Welding as an emergency repair tool in preventing costly shut-downs in maintenance of tools and equipment and in the fabrication of its far flung oil pipe lines eliminating leaks and reducing maintenance costs. The welded storage tanks, tank trucks and cars followed in due course. To meet demands for ever increasing combinations of pressures and temperatures needed in increasing efficiency in oil cracking processes, improvement of quality and development of by-products, the oil industry turned to welding. Welded vessels four and five inches thick are taken as matters of course. In the march of progress carbon steels must give way to alloy and clad steels and the advance guard of welded carbon-molybdenum and other alloy steels for high temperatures, cutting thickness of plate to less than half, is well established. The future will exact still greater requirements from the Petroleum Industry and the Welding Industry will help meet those requirements.









elding High Pressure Separator at Black, Sivalls & Bryson
elded Depropanizing Tower by Combustion Engineering Co.
ctric Welding of 40 Mi. Pipe Line. Lincoln Electric Co.

13. Gas Welding of Humble Pipe Line. Air Reduction Co.
14. Welded Surge Tanks, Scrubbers, etc. Combustion Engineering Co.
15. Welded Everdur Tank. American Brass Co.

16. Fabricating Pipe Line Connection. American Murex Corp.
17. Welding the Shell of 55,000 Bbl. Tank. Wyatt Metal & Boiler Wks.
18. Portion of Stainless Lining of De-phlegmator. Lincoln Electric Co.

19. Shop Fabricated Refinery Vessels. Wyatt Metal & Boiler Wks.
20. Welded Oil Well Pumping Unit. American Murex Corporation.
21. Propane Storage Vessel of Nickel Steel.

WELDING SOCIETY ACTIVITIES
AND RELATED EVENTS

A Message from Our President

To the Members of the
AMERICAN WELDING SOCIETY:

There came to me this week a report of the new members obtained in June. Considering that most of the local technical meetings ended in May, it is very encouraging to know that 142 new members were obtained. We now have a total of 84 Sustaining Members and Sustaining Companies. The new ones we welcomed into the Society in June are the Public Service Co. of Colorado, the Western Pipe & Steel Company of California and the Northern State Power Co. of Minneapolis. It would seem reasonable to expect that we will increase this number to 100 by fall.

I have recently had a letter from Warner Hays, our Manager, regarding his plans for the early fall. He intends to swing back over the territory where he did missionary work this spring. It is his hope and expectation to establish quite a few additional chapters before our annual meeting at Atlantic City in October, and I believe he will be able to do so. One thing is certain—there is no difference between selling washing machines and selling interest in welding. One cannot get results in either case without going to the prospect. A pep meeting in a promising welding section will do more good than a thousand letters. One has to actually tell a prospect what he has to gain by membership in the Society, has to tell him face to face. Hays has done a splendid job of this so far and I know he will continue doing so.

I am greatly impressed with the inquiries which come into our office which carry the sentence, "Welded construction preferred." This is pretty generally true of the inquiries from steel producers. It is surprising the number of other industries, ones you would think knew little of welding, who are designing their equipment for welding.

A couple of weeks ago we had a visit from the Chief Engineer of a company for whom we are building a sizable piece of equipment. I took him through our shop and as I always do, pointed out in particular various welded jobs as we came to them. I went into considerable detail to explain just what we accomplished by welding; increased strength, light weight, saving in cost and the shop burden absorbed by welding instead of buying castings. When he left he said, "I came here with the intention of telling you we didn't want any welding on our job, but with what I have seen here today, I am satisfied with any welding work you would do." I have cited this not so much for a pat on the back but to point out that all one has to do with a welding skeptic is to get him into a plant where good welding is done and explain to him the advantages.

Incidents similar to this are happening every day. Every day new converts are gotten; every day the field is enlarged and every day there are new prospects anxious to know more about welding. That's the place where the AMERICAN WELDING SOCIETY comes in—where the Society can function in bringing the latest developments of the art, the latest research, to industry in order that it may profit from that knowledge. It's your job and mine to let people know what the Society has to offer.

I am convinced that the next couple of years will produce a market for welded equipment which will dwarf what we are doing today. With this new market the AMERICAN WELDING SOCIETY should grow and prosper. This year we have made a good start; next year we should make this year's gain look insignificant. I'm mighty happy to know that the incoming president is the pusher type who will not be satisfied without real results.

While you are away fishing or motoring or just lying around on bathing beaches this summer, give a little thought about what you can do to make your local chapter of greater value to your members. While you haven't anything pressing on your mind during your vacation, if you're lucky enough to get one, (I won't), figure out who is the best prospect you know and then proceed to sell him on the AMERICAN WELDING SOCIETY.

One hundred and forty-two members in June; we can make it two hundred in September—if you get your man.

Sincerely,

A. E. GIBSON

Program Building by Sections

A review by our Managing Director

These summer months are the time of greatest activity for the officers and program committees of the sections, particularly the new ones. Most of the sections, are following the success of Los Angeles, New York and Philadelphia in developing lecture courses with the help of our home office for next winter. Other timely topics and speakers are being pledged to make the season of 1937–38 epochal in the history of each section.

Baltimore will open their season in early October as they have in the past with an oyster roast. Those famous Lynhavens can aid the welding cause and provide a greeting and jubilation evening for Baltimore's National Presidential candidate Phillip G. Lang, Jr. I enjoyed a pleasant dinner meeting with the officers and directors of that section on July 7th. They have an active year planned ahead under chairman Miller. The recent transfer of Col. Jenks and A. G. Bissell to Washington adds two very valuable active workers to that Section.

July saw the final organization meetings of the New Northwest (Minneapolis St. Paul Section). Houston, Atlanta, Birmingham, Oklahoma City, Chattanooga, Omaha and Cincinnati initial lists likewise are nearly completed.

Public Relations

Some members and sections are doing much to inform the public about benefits of welding. The Railroads have called attention to their use of this art and science and the savings realized just since welding got its foot through their front door.

Securing adoption of A.W.S. Building and Bridge Codes or their approval by authorities and specifying agencies or engineers calls for the highest type of Public Relations work. New York members deserve credit for finally bringing about the favorable action of July 20th by the Board of Aldermen.

There are many ways of publicizing welding. One effective way is to write about it in all publications read by potential users. Another is to see that a paper on welding is on any program of meetings of specifiers or users of welding. Another is to have demonstrations for those who have not yet taken it up in their construction or production processes. Such demonstrations can be in the plant or industry and exhibit or as this Philadelphia example. Philadelphia Franklin Museum has a train welding demonstration by Budd Mfg. Co. every day except Monday and Tuesday until October 31st featured as "Shot Welding" on posters in front of building and by car cards in all the trolleys, buses and elevated and subway trains. Thus, the significance of Welding is being brought to the public attention. Also Budd Co. is getting an added return on their Atlantic City Car Builders exhibit cost. In the Franklin Institute traveling "Covered

wagon exhibit" there was an exhibit and demonstration of Gas Cutting. This was on the road for two months. Business Week played up the Welders Fourth of July show in New York's Lincoln Tunnel as a cover design July 3rd issue. Metal Progress for July devoted cover and major part of issue to Welding.

On another page Business Week pointedly stated welding had made possible carrying half again as great a load on Tanker Studeerus. 20% serving in weight and stiffness.

Membership Development

Membership committees in each section are working diligently first to prepare their Primary prospect lists. That is, those engineers and architects or designing men in their areas who are not members but specifying welding. Second, every plant using welding where the basic executive first member in the Society has not yet been secured as well as the foremost contract or job welding shops whose owners or operating executives, who must know welding, are not yet members of the Society. Most every section can double its membership by just obtaining this primary list and selling them on the benefits of Society work. There are many companies supplying some equipment or supplies for welding who have one or more welding engineers or experts who are not members of the Society. These too, are live prospects either as members or associate members in any area. And finally those potential sustaining members. Every section can obtain by proper approach five or more new sustaining memberships in the Society. President Gibson, Membership Chairman Davis, the Society Officers or others are glad to write supplementary letters to gain favorable action. The Society should have by October Atlantic City convention well over a hundred sustaining members.

Will each section please both get their quota—and send into Society office the primary prospects as soon as possible? Once the prospect is contacted and considers the Society service and accomplishments, he usually joins. The urge is there. It is just a matter of letting him know there is an A.W.S. and that he is welcome to join and wanted both to increase the Society's and his own prestige.

The goal is a basic $15 membership in every welding using plant or shop in America (in the large ones this would be a sustaining member) and in every designing engineer's office using welded construction or products. If every member will secure just one new member—overnight the membership would be doubled.

Ideas Wanted

Uncle Sam carries our contact with members in the JOURNAL and other publications of the Society. Likewise he carries the daily requests and suggestions for service from the members to our home office or to the section offices listed on Page 1. But the Society will achieve its maximum of service and benefit only when each member puts his shoulder to the wheel, uses the A.W.S. codes and research in his daily work—and gets one or more new members—but most of all when he gives us the benefit of his ideas and suggestions to improve the Society's service and make it more valuable to him, more rapidly achieving the objectives of promoting the art and science of welding in the public interest.

If Its Welded Advertise It

If the products or work of your company are *welded*—urge the advertising and sales Department to feature "welded" in their copy. The Pullman Car Manufacturing Co. did this in their exhibit at Atlantic City in June—even in name on the cars shown.

Many companies are doing it. More should. This is a worthy objective for every member to help advance the art and science of welding by making the public conscious of the value of welding in welded structures and of the boon to city folks through elimination of the noise factor in erection of steel work for buildings.

Buy and wear your membership emblem—50c from your local section or Society office.

WARNER S. HAYS,
Managing Director

Safety

In a special letter to insured plants dated July 10, the Associated Factory Mutual Fire Insurance Companies called attention to the rapid increase of fires caused by cutting and welding operations, pointed out the hazards and urged necessary safeguards.

Naval Architects Show Enthusiasm for Arc-Welded Construction

At the spring meeting of the Society of Naval Architects and Marine Engineers, which was held at Chester, Pa. on June 22nd, over 300 members and guests participated in a program which pointed definitely toward the universal adoption of arc welding in future marine construction. The morning portion of the program consisted of a leisurely inspection of a large tanker being constructed in the yards of the Sun Shipbuilding and Dry Dock Co., for the Atlantic Refining Company. A paper entitled "Recent Practice in Welding Large Oil Tankers," prepared by J. W. Hudson, naval architect, and T. M. Jackson, chief electric and welding engineer, both of the Sun Shipbuilding and Dry Dock Co., had been distributed prior to the meeting in order to provide ample opportunity for discussion. This paper described the details of welding, handling and erecting the large units. The vessel described is over 18,000 tons dead weight, and 521 feet long. The entire tank space of over 350 feet in length is 100% welded and the authors considered that this is not the ultimate which may be accomplished by electric welding. Butt welding is used in all strength members, lap welding being used only in the case of brackets and vertical panel plates on the longitudinal bulkheads. The paper was illustrated with diagrams and photographs which showed both design and assembly details to excellent advantage. The authors expressed the opinion that operating results, maintenance costs and savings, will more than justify the extra expense, if any, in building welded tankers. With all of this information at hand and with ample opportunity to observe many stages of the construction work in progress and at close range, the members prepared for an interesting afternoon of discussion and were not disappointed.

The formal meeting was opened in the afternoon by presentation of a paper entitled "Some Effects of Welding on Ship Construction," prepared by Mr. James B. Hunter, head of the hull technical division of the Bethlehem Shipbuilding Corporation, Ltd., Fore River Plant, Quincy, Mass. This paper described briefly some of the effects observed in the shipyard practice and methods due to the substitution of welding for riveting. One important conclusion is that if welding takes the place of riveting in the major portions of the structure, definite modifications of shipyard practices appear inevitable. In the case of small vessels the author stated that the trend is definitely toward welding the tank spaces completely; and in the larger merchant vessels welded bulkheads both transverse and longitudinal, also major parts of the framing, small decks and flats, are being generally welded.

In both the written and the oral discussions of these two papers opinions concerning the advantages of welded construction were notably enthusiastic, although the need for further research and experimentation was duly recognized. There is evidently a definite thought in shipbuilding circles that the reduction in weight made possible by welding, together with other advantages will gradually reduce rivets to the vanishing point and classification welds will undergo gradual changes until they give full recognition to the welded ship. As a whole, the session furnished a generous exchange of ideas concerning the new problems of design, construction and organization that the shipbuilding industry is facing and left no doubts in the minds of those present that ship builders are proceding as rapidly as possible to master the application of arc welding in their business.

Structural Applications of Arc Welding

A new bulletin, copy of which has just been received from The Lincoln Electric Company, Cleveland, Ohio, manufacturers of arc-welding equipment, illustrates a great variety of applications of arc welding in the structural field, both in the

erection of miscellaneous structures and in maintenance work of construction machinery.

Resolutions—Dr. Alfred Douglas Flinn

RESOLVED: That The Engineering Foundation—Welding Research Committee hereby gratefully acknowledges its indebtedness to Dr. Alfred Douglas Flinn;

His whole-hearted devotion to the work of The Engineering Foundation made the Foundation one of the great institutions of the world devoted to the interests of scientific and engineering research;

His vision and wisdom helped to make possible the Welding Research Project and establishment of the Welding Research Committee as now organized;

His diligent and generous services were invaluable in formulating the broad policies which now govern the Committee's activities.

The Committee and the members of his staff will long cherish the memory of his modest nature and his helpful friendliness. Above all he will be remembered as a man whose personal integrity and kindliness endeared him to all.

Inspection Trip to New 100-Inch Mill of the Carnegie-Illinois Steel Corporation

Over four hundred dyed-in-the-wool steel men assembled at the William Penn Hotel and were transported by Chartered Coaches direct to the Homestead Plant where every provision was made for the convenience and safety of the guests in inspecting the huge mill in operation. With well defined walkways, extending from one end of the plant to the other, with observation platforms located at advantageous points, so that all could get close-up views of the many operations, with guides located at all points and some accompanying the guests on the trip around, all were able to get a very clear understanding of the entire operation.

With respect to the interest to the welded-minded, one could see in all directions that welding was utilized wherever possible. Many tanks, guards, platforms, railings, etc. were welded, as well as much of the mechanical equipment. However, this is becoming more and more standard practice and is taken for granted by all.

Following the inspection the guests were returned by bus to the hotel.

The AMERICAN WELDING SOCIETY was represented by Mr. J. F. Minnotte, Secretary of the Pittsburgh Section.

German Meeting

The German Chemical Society cooperating with the German Acetylene Society and the Society for Gas Welding, at their summer meeting, July 2–11, at Frankfort, devoted an entire session to gas welding. The following papers were presented:

Gas Welding Low-Alloy Boiler Steels, by G. Czernasty. (Properties of gas-welded plates and tubes in manganese—silicon steel, molybdenum steel and chromium-molybdenum steel. Filler rods of the same and different compositions were used. Creep tests were made on gas-welded chromium-molybdenum steel superheater tubes at 500° C.)

The Metallurgy of Gas-Welded Rails, by Dr. Dümpelmann. (Fluidity of filler rods; butt-welded joints without straps; wear resistance, toughness and structure of gas-welded joints.)

Gas Welding Rails in Practice, by H. Frankenbusch. (Butt-welded joints without reinforcement are recommended. Welding two different types of rails together. Welding frogs and curved rails. Ordinary rails (tensile strengths 85,000 to 130,000 psi) as well as Duplex rails can be gas welded successfully.)

The Pulsating Bending Fatigue Strength of Welded Rails, by Prof. Otto Graf. (Fatigue tests of several types of welded rail joints.)

Corrosion Tests of Welded Joints, by Dr. L. Hunsicker. (Corrosion tests on mild steel welded with neutral, oxidizing and reducing oxyacetylene flame. The oxidizing flame gave the worst corrosion resistance. Welded joints were always more noble than base metal, on account of the welding scale. Grain size is of great importance, the coarse-grained material having a more noble potential than the fine-grained (copper). The potential of acetylene welded aluminum and lead was more noble than that of oxyhydrogen welds in these metals.)

Engineering & Marine Exhibition

Members of the AMERICAN WELDING SOCIETY are invited to attend The Engineering & Marine Exhibition which will include the Foundry Trades' Exhibition and The Welding Exhibition, September 16th to October 2nd, 1937 at Olympia, London.

Members of the Society planning to attend should communicate with M. M. Kelly, Secretary of the Society.

Welding in Building Construction

Substituting Welding for Riveting in Building Construction by H. Gerbeaux, Head of Course on Welded Construction at the Institute of Fusion Welding, Paris. 135 pages, 151 figs. Price 15 French Francs. Institut de Soudure Autogène; 32 Boulevard de la Chapelle, Paris (18), France.

This book is the outcome of a lecture given by the author at the National Conservatory of Arts and Trades in Paris.

The first part deals with the general properties of welded structures: Mechanical Properties of Welded Joints; Stress Distribution; French Regulations; Shrinkage; Control of Welds.

In the second part the author discusses the application of welding to all branches of structural engineering. Numerous illustrations and diagrams show welded trusses, frames, girders, buildings, bridges, pylons and cranes.

Welded Piping Design

Complete handbook information on design and layout of piping for welded connections is contained in "Design of Welded Piping," a 200-page (6 x 9) booklet containing over 100 figures and tables, published by The Linde Air Products Company, New York.

Subjects treated of interest to engineers are fundamentals of welded joint design; welding metallurgy; standard welded pipe connections; design data on welding cast iron, galvanized iron, stainless steel and non-ferrous piping; advantageous layout; fabrication and erection considerations; welded anchors and supports; and welding speeds.

Features of interest to architects and draftsmen include standard joint designs; typical headers, expansion bends and riser connections; anchors and supports; a typical heating system layout showing symbols for welds; two sample time-saving specifications; and principal dimensions of pipe, flanges and welding fittings.

A.W.S.—Bridge Specifications

As a matter of information and interest, there is quoted below section of minutes of meeting of Committee XV, American Railway Engineering Association, held at Detroit, Mich., July 15th and 16th, 1937:

"On motion of Mr. Haggander the Committee recommended the adoption, for use, of the specification under discussion, and that the following reference be authorized by the Association for printing in the Manual:

'Specifications for Design, Construction, Alteration and Repair of Highway and Railway Bridges by Fusion Welding.'

"It is recommended that the above noted Specifications of the AMERICAN WELDING SOCIETY, adopted in 1936, be used, pending further consideration of this subject by the Committee. *Carried.*"

New York Building Code Permits Fusion Welding

The new Building Code for the city, which has been held in the committee for more than four years, will become effective January 1, 1938, replacing the code adopted in 1916. There follows a direct quotation from the *New York Times*' summary of the important changes in this code.

"WELDING—This is the second of the most important articles in the code. The first outstanding provisions are those which would permit the use of fusion welding. This process has developed very rapidly and is now generally recognized as sound when done by competent workmen and under proper supervision. It would be reactionary to prohibit entirely the use of this process in building construction when it is

used by preference in the construction of airplanes, warships, automobiles, locomotives and railroad bridges. Its use will be permitted under careful restrictions as to the qualifications of the workmen, the design and supervision of welded work."

New York's new code is the result of several years of hard work on the part of many distinguished architects, engineers and other specialists in the building field and will doubtless serve as a model for other cities. The welding industry and the AMERICAN WELDING SOCIETY owe a considerable debt of gratitude to the many loyal members of the Society who worked so long and faithfully in attending meetings, hearings, presenting evidence and other data needed by the conservative engineers who had the preparation of the New York Building Code in hand.

EMPLOYMENT SERVICE BULLETIN

POSITION VACANT

V-81. Welding Equipment Salesman to take charge of Welding Sales Dept. for state-wide distributor of nationally known products. Give complete record of experience and previous earnings.

Jennings Sails

Mr. Charles H. Jennings, Research Laboratories of the Westinghouse Electric & Manufacturing Company will sail for England on August 4th. He will spend three or four months acting as consulting welding engineer for the English Electric Company. He will probably return about the first of December.

Mr. Jennings carries with him the best wishes of the Society.

SECTION ACTIVITIES

CHICAGO

The Officers for 1937-38 of the Chicago Section are as follows:

Chairman—Tom Jones, Carnegie Illinois Steel Co.

Vice-Chairman—Homer E. Gannett, C. B. & Q. R. R.

Secretary-Treas.—F. L. Spangler, *The Welding Engineer*.

Directors for Three Years—Frank H. Carpenter, Federal Pipe & Supply Co.; I. J. Eales, Steel Sales Corp.; Robert Malcolm, Chicago Eye Shield Co.; Albert Reichman, American Bridge Co.

Director on Board of Directors—C. J. McGregor, American Steel & Wire Co.

The following officers remain in office until the expiration of their terms:

Directors Whose Term Expires in One Year—Gale Adams, Goodman Manufacturing Company; R. G. Mason, A. T. & S. F. Railroad; R. R. McFarland, Western Electric Co.; E. L. Quinn, American Manganese Steel Co.

Directors Whose Term Expires in Two Years—J. Kinsock, Standard Oil Co. of Indiana; Leslie McPhee, Whiting Corp.; G. E. Tenney, The Lincoln Electric Co.; D. C. Wright, Sears, Roebuck & Co.

HAWAII

The first regular meeting of the Hawaiian Section of the AMERICAN WELDING SOCIETY was held on May 27th at the Oahu Country Club. It was agreed that the fourth Tuesday of each month be designated as the regular Section meeting night. By-Laws were adopted at the meeting and the following officers elected:

Chairman—E. E. Heacock
Vice-Chairman—G. Hansen
Secretary—R. L. Mullen
Treasurer—J. K. Mardick

Executive Committee for two years—H. Ryan, Geo. M. Ross, C. E. Jensen

Executive Committee for one year—Robt. Plaus, P. Orso, W. E. Smith.

MARYLAND

At a recent meeting of the officers and members of the Executive Committee of the Maryland Section, it was decided to have the annual Oyster Roast in October as the first meeting of the season.

Lectures of interest to all members will be given on the third Friday in November, February, March, January and April at the Engineers' Club of Baltimore.

Chairman Miller appointed members on Membership, Program and Oyster Roast Committees. Members were also appointed to assist the Philadelphia Section at the Annual Meeting of the Society in Atlantic City.

WESTERN NEW YORK

Mr. F. O. Howard of the American Steel & Wire Company was appointed the representative of the Western New York Section on the National Board of Directors.

Notice Sept. 15th Is Last Date For Papers To Reach Journal Editor

Anyone desiring to compete for Lincoln medal for the best paper presented during this year, including October convention papers, must have them in the Editor's hands not later than Sept. 15th. Papers for September Issue of Journal must reach Editor not later than August 14.

MARTIN P. KORN
CONSULTING WELDING ENGINEER
Ellicott Square Buffalo, N. Y.

Los Angeles Educational Course

The Society has been advised that printed copies of the Educational Course given by the Los Angeles Section and announced in a previous issue of the JOURNAL can be purchased at $5.00 a set. This price is the same as charged to students of the course. The course has been successful both for its educational value and the new members secured. One lecture of this course, namely, the one by Mr. Whittlesey on Design of Connections was reproduced in the July issue of the Journal starting on page 17.

Inquiries should be addressed to

Mr. Turner C. Smith

A.W.S. Pacific Coast Division 2525 East 37th Street Los Angeles, Calif.

WELCOME

to WELDING HEADQUARTERS

at the NATIONAL METAL CONGRESS

AS Headquarters for the Welding Society of the National Metal Congress here during the week of October 18th, we're all ready to give you Welding Engineers a warm welcome—and every bit of cooperation during your stay!

Here, waiting for you, are your really large sleeping rooms overlooking the ocean. Here is delicious food to satisfy appetites made keen by bracing sea air. Here are broad sun decks, fellowship at the bars, entertainment in the Submarine Grille, good golfing, and horseback riding on the beach.

Rates represent exceptional values. May we expect your reservation soon?

The

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Bennett E. Tousley

General Manager

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